THE SEA-MANS PRACTICE,

CONTAINING

A FUNDAMENTAL PROBLEM

IN

NAVIGATION,

Experimentally verified;

NAMELY,

Touching the Compaſs of the *EARTH* and *SEA*, and the quantity of a Degree in our *Engliſh* Meaſures.

ALSO,

An exact Method or Form of keeping a Reckoning at *SEA* in any kind or manner of Sailing.

With certain *TABLES* and other *Rules* uſeful in *Navigation*; As alſo in the *Plotting* and *Surveying* of *Places*. The *Latitude* of the Principal Places in *ENGLAND*. The finding of Currents at *SEA*, and what Allowance is to be given in reſpect of them.

THE TWELFTH EDITION.

By *RICHARD NORWOOD*, Reader of the *Mathematicks*

LONDON,

Printed for *William Fiſher* Bookſeller, at the Poſtern-Gate near *Tower-Hill*, and *Eliza. Hurlock* at the *Roſe* at the Weſt-end of St *Pauls*, 1676.

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THE SEA-MAN'S PRACTICE.

CONTAINING

A Fundamental Problem

IN

NAVIGATION,

Experimentally verified;

NAUTICAL,

Resolving the Compass or the Vth and VIth Case of Sph. Trig. and the quantity of a Degree in our English Miles.

ALSO,

The Theory and Description of Three New Sea-Quadrants, The Use of Which Performs in a Clear Manner The Building of Plain Scales, Projected to be Equal

THE SECOND EDITION

By ROBERT GOFTON, A Master of the Mathematicks

LONDON,

Printed for J. Lacy, 1677.

To the right Honourable

ROBERT

Earl of *WARWICK*,

Baron of *Lees*, &c.

Right Honourable,

ALthough the Knowledge and Practice of the Art of Navigation be of late years grown to a far greater perfection than it can appear to have had in any former Age; and by that means the World, and all the parts thereof, have been further discovered, yea, sailed round about; the Traffick and Entercourse of several Nations, how remote soever, facilitated; and (which, as I conceive, is of most importance, seeming as yet to be the principal scope of the Divine Providence in discovering these Mysteries) the light of the glorious Gospel of Christ, being the mighty power of God unto salvation, is extended to those silly captives of Satan in *America*, by means of those many Plantations we have amongst them; which Plantations (even from their first breathing) have received no small furtherance from your Noble favour and bounty, as I know by my own experience in that where sometimes I was, and have understood no less by others in the rest.

Yet notwithstanding this notable growth and daily exercise of the Art of *Navigation*, it still remains imperfect in some points. For whereas the practice thereof doth especially consist in the knowledge of Latitudes, Courses and Distances; the way of finding distances at Sea, namely, by the *Log* and *Line*, is rather opinionative and conjectural, than certain; being grounded upon this supposition, that the Compass of the World in any great Circle is 21600 *Italian* Miles (as they call them) and that such an *Italian* Mile contains 1000 Paces, and every of those Paces 5 *English* Feet; and according to these measures they divide their *Log-line*, and keep their account of the Ships way at Sea.

Having therefore by an Experiment which I made a year since, found more nearly the Compass of the Earth, and the quantity of a *Degr.* on the same in our known measures, and applied it to use in *Navigation*, in this Treatise following, and further added some other such things as I conceived to be wanting in the Practice of that Art: I have presumed to present it to your Lordship, as well because by your knowledge in *Navigation*, and the experience you have had in your Honourable Enterprizes at Sea, you are well able to judge of it; as also being confident that according to your Noble disposition you will favourably accept thereof, though otherwise of it self unworthy. The most high God ever Blessed and Glorious, multiply unto your Honour all his Blessings in Christ Jesus.

Your Honours in all due observance,

RICHARD NORWOOD.

To the READER.

THe Circuit of the Earth and Sea (as the Circumference of every Circle) contains 360 degr. by which degr. the diſtances thereon are meaſured, ſo that the knowledge of the quantity of ſuch a degr. in our known meaſures, is a fundamental Principle in Coſmography and Navigation, as upon which is grounded the reckoning of the Ships way, or diſtance run. For though a Mariner being in his Voyage on the vaſt Ocean, hath ſometimes three things to certifie him where he is, and how to ſhape his Courſe to his deſired Port, namely, his Latitude, Courſe, and Diſtance; and ſometimes a fourth, namely, ſome neer conjecture of his Longitude by the Variation, or otherwiſe; yet oftentimes (as in cloſe weather) he hath nothing but his Courſe and Diſtance; otherwhiles only his Latitude and Diſtance is his chief guide in falling with his intended Port. I know it is uſual to allow neer 7 Fathoms or 41 $\frac{2}{3}$ Feet to a Knot, and ſo many of thoſe Knots as runs out in half a Minute, ſo many Miles they account the Ships way to be in an hour. And if in half a min. ſhe run 41 $\frac{2}{3}$ Feet, then in 60 min. or an hour, ſhe runs 5000 Feet; and thus they account 5000 Engliſh Feet, or 1000 Paces to be a Mile, and 60 of thoſe Miles to be a degr. ſuch as the whole Circumference in any great Circle is 360. But how is this known to be true? If it be anſwered, that it is known to be ſo by Experience; then I would know further by what Experiment this was found to be ſo? Where, and by whom made? I preſs this ſo much the rather, becauſe I am perſwaded we have at this day as many excellent Navigators in this Kingdom, and as great Voyages performed, as from any other place in the World; and I ſhould be glad to hear of the experimental reſolution of this Problem by ſome of them, though it were but in running 8 or 10 degr. near the Meridian: for ſo I doubt not but that which I have here written thereof, would receive further confirmation, and better entertainment, than happily it will now, being ſo much different from the common opinion, and the Arts of Navigation and Coſmography, would be much more perfected in ſhort time. For one Errour (as a fruitful Mother) is oftentimes the cauſe of more, and ſo the removing of one is the occaſion of removing others, eſpecially when they do mutually ſupport one another: As we ſhall here ſhew how the Errour in the projection and uſe of the common Sea Chart, is ſupported by this Errour of accounting only 300000 of our feet to a degr. and this in like ſort upheld by that, ſo that they will ſtand or fall together. And ſurely that had fallen long ſince, being ſo manifeſtly convinced, if it had not been upheld by this. For the confuting

confuting of that (I mean the common Sea-Chart) it was sufficient to know that the Earth and Sea make one Spherical Body, but in disproving and rectifying this, it is necessary to know moreover what is the quantity of that Spherical Body: And to that end, it was necessary to make a sensible application of our known Measures to a determined part of the whole, that so the quantity of that determined part being known, and the proportion thereof to the whole, the quantity of the whole might also be discovered. And this I have endeavoured in the Experiment following, which if I have not handled so exactly in all points as some would desire (that requiring more time and charge than I could well bestow) yet I doubt not but it will be found that I have come very near the Truth. Some happily will censure me for being my self at the expence to make such an experiment: But I was as frugal in it as I could, adding pains and industry to save expence; I came up in 10 or 11 days, and had other necessary occasions to lead me from the one place to the other, and did this as a thing falling opportunely in my way: But indeed (as in all other parts of Learning) so in the Mathematicks, especially in their application, or middle Mathematicks (as some call them) it is necessary, with Speculation to joyn actual and experimental Practices; the former being empty and uncertain without these. It is true, that the Mathematicks afford large Fields of delightful Speculations, wherein a man might walk far with much pleasure: But if from so many fair Flowers, he bring home no Honey, or from such large Fields no Sheaves; I mean, if he bring not those Speculations to some useful Practices, neither himself nor others are like to receive much fruit by them. But this indeed cannot be effected without more labour and difficulty; yet sometimes it requires Mechanical and Bodily exercises, which some esteem too mean and unworthy to stoop unto. But for mine own part, I acknowledge to have had my living and maintenance by the Mathematicks, and not by Speculation only, but rather by my practice therein; and therefore also I desire (what in me lies) to make them fruitful to my self and others; and to that end have spent in some principal parts of the Mathematicks, near as much time and means in experimental Practices and Conclusions, as in the Speculation: Moreover, considering that this particular experiment was proposed above 30 years since, by our Countreyman Mr. Edward Wright, to invite some to the trial of it, as a thing which he would have done himself, if he had found such furtherance and opportunity as he desired, which it seems he did not, nor any other since that time. Rather than so noble and so necessary a Problem should longer rest unresolved, I took the opportunity offered, hoping it may be an occasion to whet on some others to do the like. This, with some other things which I conceived to be wanting in the practice of Navigation, I have handled in this ensuing Treatise, which I commend to your friendly acceptance. Farewel.

July the first, 1636.

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SEA-MANS Practice.

CHAP. I.

The common Opinion touching the Compaſs of the Earth, and quantity of a Degree of the ſame.

IT is a common received Opinion in *England* (and the like is in other places) that allowing 5 of our *Engliſh* Feet to a Geometrical Pace, 1000 of thoſe Paces make an *Italian* Mile, and 60 of thoſe miles in any great Circle upon the Spherical Surface of the Earth or Sea, make a Degree; and thus it is ſuppoſed, that a Deg. contains 60 miles, or 60000 Paces, or 300000 of our *Engliſh* Feet, and by ſuch miles do Mariners in their Voyages by Sea keep their Reckonings: And becauſe the whole Circumference of a Circle is 360 Deg. therefore the compaſs of the Earth, according to this Opinion, ſhould be 21600 ſuch *Italian* Miles, or 21600000 Paces, or 108000000 of our Engliſh Feet. Whence this Opinion came, or upon what Experiment it ſhould be grounded, I cannot certainly ſay; It may ſeem to be taken, or rather miſtaken from *Ptolemy*, who ſaith, there

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are 500 *Stadiums* in a Degree, the ſame was before affirmed by *Martinus Tyrius*, of whom *Ptolomy* ſpeaking in the 11th Chap. of his firſt Book of *Geography*, hath theſe words, *Sed in hoc quoque recte ſentit partem unum qualium eſt circulus maximus tricenarum ſexaginta, quingenta in terra conſtituere Stadia, id enim confeſſis dimenſionibus conſonum exiſtit.* Now a *Stadium* not only amongſt the *Greeks*, but as appears by *Herodotus*, amongſt all other Nations of *Aſia*, and in *Egypt*, did conſiſt of 600 Feet, or 100 *Orgyas*, an *Orgya* containing 6 Feet or 4 Cubits, as our Fathom doth; the ſame alſo is teſtified by *Suidas* and others: ſo that a *deg.* containing 500 *Stadiums*, and every *Stadium* 600 Feet, it follows that a *deg.* muſt contain 300000 Feet, exactly agreeing in number with the common received opinion in *England*, which therefore may ſeem to be hence derived, and would alſo receive much confirmation hereby (he being an Author of ſuch approved credit) if it could be approved that our *Engliſh* Feet were exactly equal to the *Egyptian* or *Alexandrian* Foot, where *Ptolomy* wrote. Otherwiſe that being true, that ſo many of their Feet make a *deg.* it will follow, that if ours be greater, there be fewer of them contained in a *deg.* if leſſer (as undoubtedly they are) there muſt be more of them contained in a *deg.*

Philander in his Commentary upon the third Ch. of the third Book of *Vitruvius*, hath expreſſed the quantity of the ancient *Roman* Foot, where (by a competent allowance for the ſhrinking of the Paper being printed wet) it may probably be gathered that it was ſomething longer than our *Engliſh* Foot. But the *Alexandrian* and *Egyptian* Foot was much greater; for according to *Heromechanicus*, 5 *Alexandrian* Feet were equal to 6 *Roman* Feet; ſeeing then the ancient *Roman* Foot was ſomething greater than ours, the *Alexandrian* muſt needs be much greater than ours. So that whereas *Ptolomy* ſaith there are 500 *Stadiums* in a Degree, and as we have ſhewed a *Stadium* did conſiſt of 600 Feet, theſe being *Egyptian* or *Alexandrian* feet, as it is moſt probable, being the place where *Ptolomy* lived, there muſt be a far greater number of our Feet in a *Stadium*, and ſo in a Degree; whence it is evident that there is no ſufficient footing for this common opinion in the aſſertion of *Ptolomy*.

Neither

Neither doth the Practice and Experience of Marriners in their Voyages at Sea prove it; for there is no reckoning or experiment at Sea ſet down by any (that I have ſeen) to confirm it. And though it be true, that in ſailing between two places that lye near to one and the ſame Parallel, they ground their reckoning chiefly upon this ſuppoſition, that 300000 of our *Engliſh* Feet make a Degree, yet can they ſeldom or never by thoſe reckonings diſcern the Errour, the rather for that they have been, and for the moſt part are ſtill kept upon the Plain or Common *Sea-Chart*, which makes a Degree in any Parallel equal to a Degree in the Equinoctial, and ſo makes a Degree in any Parallel to contain 300000 Feet: And it is true, that in ſome Parallel a Degree doth contain only 300000 of our *Engliſh* Feet; namely, about that Parallel which is in Latitude 35 Degrees (as we ſhall further ſhew hereafter) near unto which have the principal of our Eaſtern and Weſtern Voyages been made. And thus, though this opinion of 300000 Feet in a Degree, and the Projection of the *Common Chart* be both erronious; yet becauſe the errour of the one doth ſomething ſalve the other, they could not be ſo eaſily diſcerned by Experience only.

This opinion of 300000 *Engliſh* Feet to a Degree, may ſeem alſo to be ſomething confirmed by an obſervation made by our Countrey-man Maſter *Edward Wright*, upon Mount *Edgecomb* near *Plimouth*, of the Semidiameter of the Earth, which he hath ſet down in his Book, *Of the Correction of Errours in Navigation*, Chapter 15. where he finds the Semidiameter to be 18312621 of our *Engliſh* Feet, whence it may be gathered, that in a Degree of a great Circle of the Earth, there ſhould not be full out 320000 of our Feet; but the way by him then uſed, though it was very fit for the end whereunto he there applies it; namely, to find the dipping or depreſſion of the apparent Horizon beneath the true, according to the heighth of the Eye above the Water; yet will it eaſily be granted to be no exact way for finding the Semidiameter, and conſequently the Circumference of the Earth, or the Quantity of a Degree

on the ſame; and ſo he ſayes there, that he uſed that way, becauſe he wanted opportunity to put in practice a more exact way. Wherefore for the further ſatisfaction of my ſelf and others in this Point, and chiefly for the neceſſary uſe it hath in the Practice of *Navigation*, I have made the experiment following, that ſo the quantity of a Degree, and of the whole Compaſs of the Earth, might at leaſt-wiſe be nearly known in our *Engliſh* Meaſures.

CHAP. II.

An Experiment made for finding the quantity of a Deg. *and ſo the Circumference of the Earth and Sea in our known Meaſures.*

HAving occaſion to be in the City of *York*, about the beginning of *June*, *Anno* 1635. I made there ſeveral Obſervations of the Meridian Altitude of the Sun, the laſt of which was made the 11 day of *June*, the Skie was every of thoſe days ſomething overcaſt at Noon, yet not ſo much but that an Obſervation might be made to near a ſcantling: And becauſe the laſt of thoſe Obſervations is moſt fit for the preſent occaſion, and that Day was as clear as any of the other, we will here eſpecially make uſe of that, being as followeth.

Upon the 11 of *June* 1635. I made an Obſervation near the middle of the City of *York*, of the Meridian Altitude of the Sun, by an Arch of a *Sextant* of more than 5 Foot Semidiameter, and found the apparent Altitude of the Sun that Day at Noon to be 59 *deg.* 33 *min.*

I had alſo formerly upon the 11 Day of *June*, *Anno* 1633. obſerved in the City of *London*, near the Tower, the apparent Meridian Altitude of the Sun, and found the ſame to be 62 *deg.* 1 *min.*

And seeing the Suns Declination upon the 11 Day of *June* 1635, and upon the 6th Day of *June* 1633, was one and the same, without any sencible Difference; and because these Altitudes differ but little, we shall not need to make any alteration or allowance, in respect of Declination, Refraction, or Parallax: Wherefore Substracting the lesser apparent Altitude, namely, 59 *degr.* 33 *min.* from the greater 62 *degr.* 1 *min.* there remains 2 *degr.* 28 *min.* which is the Difference of Latitude of these two Cities, namely of *London* and *York*.

Also by the aforesaid Observation made in *York*, it appears, that the latitude of that City, is 53 Degrees, 58 Minutes almost.

But to our purpose; Coming at that time from thence to *London*, I further found by Measure, that the Parallel of *York*, is from the Parallel of *London*, 9149 Chains; every Chain being 6 Poles, and every Pole $16\frac{1}{2}$ of our *English* Feet; that is every Chain 99 Feet. (After what manner I found this to be so, we shall further express hereafter:) But thus, as I say, I found that *York* is more Northerly than *London* by 9149 Chains: And before we have noted that these two places differ in Latitude 2 Degrees 28 Minutes: therefore it follows, that 2 Degrees 28 Minutes of the Meridian of the Earth and Sea, is equal to 9149 Chains. And if accordingly we would know how many of these Chains are contained in 1 Degree, we may find that by the Rule of Proportion, first reducing the Degrees into Minutes, and then say,

If the difference of Latitude	148 *co. ar.*	7.82974
give such a number of Chains.	9149	3.96137
Then 1 Degree, that is	60	1.77815
gives of such Chains	3709	3.56926

and somewhat more, namely, 5 Feet, which reduced into Feet make 367196; that is, 367200 Feet in a Degree, lacking 4 Feet, which here we regard not.

Thus then, according to this Experiment, it is evident, that one Degree of a great Circle measured on the Earth is near 367200 Feet, which in our Poles of $16\frac{1}{2}$ Feet, is 22254 Poles, and about one half; and these reduced into Furlongs, at 40 Poles to the Furlong, make 556 Furlongs and 14 Poles: and lastly, these reduced into our *English* Miles, of 8 Furlongs to a Mile, make 69 Miles, and 4 Furlongs 14 Poles, that is $69\frac{1}{2}$ Miles and 14 Poles in a Degree.

And hence, according to the most approved *Hypothesis* of the Sphericity of this Terrestrial Globe, we may find the Compass of it as followeth. But first, you may Note that we speak not here of the Compass of the Earth in any Parallel, or lesser Circle described upon any side thereof, that being various (according to the different distance of those Circles from their Poles) but of the Compass taken in the middle or greatest thickness of the Globe; namely, in any great Circle, such as divide the whole Globe into two equal parts, of which kind are the Equinoctial and all Meridians, *&c.* this being properly the *Perimeter* or *Compass* of a *Spherical Body.*

Now seeing a Degree is the 360 part of the Circumference of a Circle (for any Circumference being divided actually or by supposition into 360 equal parts, those parts are called Degrees) if we can find how many Feet, Paces, Miles, or other known measures are contained in one of those Degrees, then shall we easily conclude how many of the same known measures are contained in the whole Circumferenee: But by the former Experiment we find, that in one *deg.* of a great Circle on the *Spherical Superficies* of the Earth there is contained 367200 Feet; therefore it is evident that 360 times 367200 Feet is the Compass of the whole; wherefore multiplying 367200 by 360, the Product is 132192000 Feet, which reduced into Poles is 8011636; and these reduced into Furlongs, are 200290 Furlongs 36 Poles: and lastly, these reduced into Miles, are 25036 *English* Miles, and somewhat more, for the Circuit of the Earth and Sea.

If further we desire the Diameter and Semidiameter of the Earth: Forasmuch as it is proved by *Archimedes*, that the proportion of the Circumference of a Circle is to the Diameter thereof, almost as 22 to 7: Therefore by the Rule of Proportion, as 22 to 7, so is the Circumference of the Earth to the Diameter thereof: So that multiplying the Circumference of the Earth, namely, 132192000 Feet by 7, and dividing the Product, namely, 925344000 by 22 the Quotient, namely, 42061090 is the Diameter of the Earth in Feet, the half whereof, namely, 21030545 Feet is the Semidiameter of the same, being 21 millions of Feet, and somewhat more: these reduced into *English* Miles, as before we did the Circumference, shew the Diameter of the Earth to be 7966 Miles, and somewhat more, and the Semidiameter 3983. And thus we have the Circumference, Diameter and Semidiameter of the Earth, as also the Quantity of a Degree of the same Circumference in known measures of Feet, Furlongs, and Miles, *&c.* There are only two things here, which may seem doubtful; namely, the Experiment it self, and the *Hypothesis* of the Sphericity of this *Terrestrial Globe*, consisting of the Earth and Sea; for these being admitted, the measures thence reduced as before, will necessarily follow.

Now touching the Experiment; I confess, that to have made it so exactly as were requisite, and in all Points, so as I shall shew in the Chapter following, would have required much more time and expence than mine ability would reach unto; Yet having made observation at *York*, as aforesaid, I measured (for the most part) the way from thence to *London*; and where I measured not, I paced; (wherein through Custom I usually come very near the truth) observing all the way as I came, with a Circumferentor all the principal Angles of Position or Windings of the way (with convenient allowance for other lesser Windings, Ascents and Descents,) and these I laid not down by a Protractor after the usual manner, but framed a Table much more exact and fit for this purpose, as we shall hereafter shew; so that I may affirm the experiment to be near the truth.

Touching

Touching the *Hypotheſis*, that the Earth and Sea make one Spherical or round Body, it is generally agreed upon by all the principal Philoſophers, Aſtronomers, Geographers, and Navigators, Ancient and Modern: Some reaſons demonſtrative, for the confirmation thereof, may be theſe.

Firſt, the Eclipſes, eſpecially of the Moon, which are cauſed by the ſhadow of the Body of the Earth, being interpoſed between the Sun and the Moon; and foraſmuch as this ſhadow doth fall upon the Moon, alwayes and upon every ſide Circular, and ſo appears to us, it is manifeſt by the Opticks, that the Earth from whence it proceeds is a Spherical Body.

Secondly, Likewiſe the Eclipſes of the Sun, which are cauſed by the interpoſition of the Moon between the Sun, and thoſe places where it appears Eclipſed; I ſay, it could not be determined when, and in what place ſuch an Eclipſe ſhould appear, and where not, if the form of the Earth were not known: but ſeeing the places where ſuch Eclipſes happen, and where not, may be, and are uſually determined and that upon this Ground, that the Surface of the Earth is Spherical, it is thence alſo ratifyed to be a truth.

Thirdly, the Sun, Moon, and Stars do riſe and ſet, and are upon the Meridian ſooner to thoſe that are reſident in the Eaſtern parts, than to others more Weſterly, and that in a proportion anſwerable to the roundneſs of the Earth, as the Planets and Stars are upon our Meridian at *London* ſooner by almoſt 4 hours, than they are to thoſe that Inhabit *Summer Iſlands*, and the confines of *Virginia* and *New England*: And ſo in *Eaſt-India*, and other Eaſtern Regions, the Sun and Stars are ſooner upon their Meridian than upon ours; which is manifeſt to be ſo, as by other reaſons, ſo eſpecially by the Eclipſes of the Moon: for an Eclipſe of the Moon hath not in it ſelf any diverſity of time, being at one and the ſame inſtant without reſpect of places, yet becauſe in the Eaſtern parts the Day is begun, and it may be far ſpent before it begin in places far Weſterly, therefore ſuch an Eclipſe may appear to the Eaſtern Inhabitants towards the end of their Night, which to the Weſtern appears in the beginning

gining or middle of the ſame Night with them, and ſo the difference will be more or leſs, according to the different diſtance of thoſe places in Longitude.

Fourthly, Furthermore we ſee, that going or Sailing to the Northwards, We have the Artick Pole and Southern Stars more elevated, and the Antartick Pole and Southern Stars more depreſſed, the Elevation Northerly increaſing equally with the depreſſion Southerly, and either of them proportional to the Diſtances which we go: The like happeneth in going to the Southwards. Beſides the Oblique Aſcenſions, Deſcenſions, Occultations, Emertions, and Amplitudes of Riſing and Setting of the Sun and Stars, in every ſeveral Latitude, agreeable to the *Hypotheſis* of the Earth's Sphericity; All which could not be ſo, if the Earth were of any other than of a Spherical form.

Fifthly, So if we ſtand upon the Sea-ſhore, and ſee a Ship far off under Sail, making towards the Land, at firſt we ſee only the Top-Sails or higheſt parts, and withall do manifeſtly behold the Convex Superficies of the Sea, as it were raiſed and interpoſing her ſelf between our ſight and the Hull, or lower parts of the Ship, till ſhe approacheth nearer, and this uniformly, every wayes alike, and proportionably to the ſeveral Diſtances; which doth evidently demonſtrate the Spherical roundneſs thereof.

Sixthly, And laſtly, (to add no more) the Navigations of theſe later times make it apparent, thoſe eſpcially that have been made round about the World, as thoſe two Voyages by our famous Country-men Sir *Francis Drake*, and Mr. *Thomas Candiſh*, both which ſeverally Sailing from our Coaſts to the *Weſt-Indies*, and paſſing the Streights of *Magelane*, continued their Courſe Weſterly, till they came into thoſe parts, which are from us to the Eaſtwards, namely, to the *Eaſt-Indies*, and ſo Sailed ſtill Weſterly till they came to *Cape bon Eſperance*, and thence returned into *England*: Having Sailed about the whole Terreſtrial Globe, they found nothing by their obſervations or Reckonings diſſonant from the uniform *Sphericity* thereof in all its parts. That they came ſhort in the number of Days, one, or reckoned the time of their abſence leſs by one Day and a Night than they

which

which remained at home; this further confirms the thing in hand.

Yet whilſt we ſpeak here of the Roundneſs of the Earth and Sea, we intend it nor ſo ſtrictly as if it were a thing turned round without any inequality to its Superficies: But as a Bowl or Ball, though it have ſome duſt or ſmall grains of Sand cleaving thereto, may ſtill be ſaid to be round: So, though the Land, Hills, and Mountains be ſomewhat raiſed above the Spherical Superficies of the Sea; and if there ſhould be alſo ſome Valleys or Botroms more depreſſed; yet ſeeing the greateſt of theſe inequalities have ſcarce any ſenſible proportion of the whole, we may well affirm the whole to be round.

The Relations made of the Prodigious height of ſome Mountains, as to be 60 or 70 Miles high, if it be underſtood of their perpendicular or direct height, are fabulous; the Mount *Atlas* Recorded by ſome of the Ancients, to reach up almoſt to the Moon, and to be as it were a Pillar for the Heavens to reſt upon, being meaſured Geometrically by *Eratoſthenes*, the perpendicular or upright height from the top thereof to the Valleys beneath, was found not to exceed 10 *Stadiums*, which of our *Engliſh* meaſures is little more than a Mile and a quarter, a *Stadium* not much differing from our Furlong; and the like might be ſhewed of others.

But if we admit the higheſt Mountain to riſe perpendicularly above the Spherical Superficies of the Sea 2 Miles; yet ſeeing the Diameter or whole thickneſs of the Earth, is, as we have before ſhewed, 7966 Miles, this exorbitancy or difference of 2 Miles is of ſmall moment; yea, if there were any Mountain 8 Miles in height upright, yet this compared with the whole thickneſs of the Earth, is little more than one thouſand part thereof, therefore we may conclude, that this *Terreſtrial Globe*, conſiſting of the Earth and Sea, is *Spherical*. We come in the next place to ſhew by what way of meaſuring we found the Parallel of *York*, to be diſtant from the Parallel of *London*, 9149 Chains. And ſo how the Diſtance of the Parallel of two Places may be exactly meaſured.

CHAP. III.

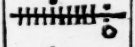
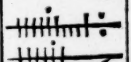
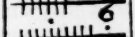
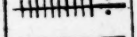
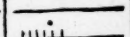
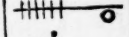
CHAP. III.

A most exact way for finding the quantity of the Diameter and Circumference of the Earth and Sea, and of a Degree on the same.

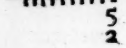
I Do the more fully set down the way of making this Experiment, that so I may give occasion to any who are so Nobly minded for a Publick good, as to be at that Charge to make a further and more exact tryal thereof. Now then, the best and perfectest way is, to observe so exactly as may be the Summer *Solstitial Altitudes* of the Sun at two places, so far distant asunder, and lying so near North and South each from other, with so direct and fair a way betwixt them, as conveniently may be chosen: Suppose for Example, *Christ-Church* and *Berwick*, or some other place in the furthest parts of *Scotland*, for the further these two places are each from other, the more perfectly may this business be performed. Then measure as truly as is possible, and set down in a Book, all the way between those two places, with all the Windings, Ascents and descents that are therein, whereby with the help of the ensuing Table, you may easily and exactly find how much the one place is more Southerly than the other. For this purpose the *Plain Table* is not the fittest Instrument, or rather a *Theodolite* or *Peractor*, or some other of that kind, observing diligently the Variation of the Needle. The Chain may be 6 Poles long, or rather a 100 Feet, and the Table fitted accordingly (but the Table following is for Poles) if it should be much longer, it would be too heavy.

The High-ways are commonly crooked; yet because of sundry obstacles and impediments which are incident out of the way, and because a man cannot certainly at first direct himself the neerest and best way to the place intended, it would be expedient to measure the Distance as aforesaid; First, in the High-ways

leading from the one to the other, and then in the neareſt and beſt way that could be choſen between them; and ſo if any notable Errour happen in the one, it may be diſcovered and amended in the other. The form which I obſerved in ſetting down the meaſures and Angles, was according to this Example.

Deg.	*Diſtance*	*North.*	*South.*	*East.*	*Weſt.*
S E 31					
S E 20					
S E 13					
S E 13					
S W 02					
S E 05					

It is to be underſtood, that the Table here following was before Calculated to ſerve inſtead of a *Protractor*, for a *Circumferentor*, or other Graduated Inſtrument, and for a Chain of 3 Poles, which for the moſt part I uſe; yet it may very well be applyed to a Chain of 6 Poles, (as in this buſineſs it was) reckoning every Chain to be two, *&c.* And thus for every ten Chains of ſix Poles to a Chain, I make two Strokes, ſignifying to Changes or 20 Chains; and if there be any odd Chains, for thoſe I ſet a Figure in another Line next below; and if moreover any odd Poles, whether one or or two, for thoſe I ſet another Figure in the third Line below.

Thus the laſt entrance before-going, being *S E* 05 *degr.*  ſignifies that the Line upon which I went, was

from

from the South part of the Meridian to the East-wards, making an Angle with the Meridian of 5 *degr.* the 9 Strokes signifie 9 Changes, or 90 Chains; the Figure 5 signifieth 5 Chains, and the Pigure 2 two Poles. So that it is to be read thus, South-Easterly 5 Degrees, 9 Changes, 5 Chains, and 2 Poles; and the like is to be understood of the rest. But for the most part having liberty of Ground, I end the measure of every Line, either with a whole number of Changes, or at least of Chains.

And thus proceeding all Day, towards the Evening, or when else I have time convenient, I reduce all these Distances, upon what Lines or angles soever they be, to Distances of North or South, East or West, as here appears.

Deg.	*Distance.*	*North.*	*South.*	*East.*	*West.*
			2571	1545	
S E 31			2819	1026	
S E 20			1692	616	
			0169	062	
S E 13			2923	675	
			1754	404	
S E 13			1499		052
			2690	231	
S W 02			0149	013	
S E 05			0020	002	
Chains.	571		16287	4578	052
	2		0	52	
Poles.	1715		16285	4525	

We will explain the last, and so the rest may easily be understood; *S E* 5 *deg.* 5.2. Here because I have *S.E.* the numbers taken out of the Table must be put in the Columns entituled *South* and *East*. Then in the Table under 5 *deg.* I look

for 9 Changes, and find againſt it 2690, and in the adjacent Column under the Complement thereof 235, and becauſe *S E* 5 *degr.* is leſs than 45 *degr.* that is, nearer to the South than to the Eaſt. I put in the Column entituled South 2690, and in that entituled Eaſt 235, then again in the ſame Tabular Column under 5 *degr.* I find againſt 5 Chains (cutting off a Figure, becauſe 5 Chains is but the tenth part of 5 Changes) 149 to be put in the South Column, and 13 for the Eaſt Column.

Laſtly, Againſt 2 Poles I find for the South Column 20, and for the Eaſt 2; and the like is to be underſtood of all the reſt.

Now ſuppoſing this laſt to be a Place, whoſe Diſtance and Situation from the firſt is required; I ſum up the Colmmns ſeverally, and of the North and South Columns Subſtract the leſſer from the greater, and ſo of the Eaſt and Weſt Columns; and ſo it will appear how much North or South, and how much Eaſt or Weſt the laſt place is from the firſt.

As in this Example, we find the laſt place to be the Southwards of the firſt 1628 Poles, for the laſt Figure may be cut off, being uſed in the Table, only for the more exactneſs, or may be made a Fraction, and ſo it is 1628 $\frac{6}{10}$ Poles; Likewiſe, the laſt place is to the Eaſtwards of the firſt 452 $\frac{6}{10}$ 5 Poles; and thus I proceed all the way.

Now touching the Angles of Aſcent and Deſcent of Hills and Valleys, to have obſerved them exactly, would have required more Time and Charge than I could of my ſelf beſtow; yet I made allowance for ſuch of them as were of moſt moment; He that would obſerve them all, may either make 2 or 3 Columns more, or keep an account of them apart by themſelves. But if he intend no further uſe of them, but to find the neareſt diſtance, he need not ſet them down, but make allowance for them on the Ground, keeping his Diſtance intire without Fractions.

As, admit I obſerve the Aſcent from a Valley to the brow of a Hill to be 14 *degr.* above the Level or Horizontal Line, and that meaſuring, I find the Diſtance to be 30 Poles; I turn to the Table, and under 14 *degr.* and againſt 10 Chains, I find 2911, and 726, ſhewing that the Level or Horizontal Diſtance from

my

my Station, to that Brow, is only 29 $\frac{11}{100}$ Poles, and that the height of that Brow above the Level Line, is 7 $\frac{36}{100}$ Poles: But finding thus that the *Hypothenusal* being 30, the Base or Level Line is but 29 $\frac{11}{100}$, that is less by $\frac{89}{100}$, because I would avoid this Fraction, I add to the end of the foresaid measure of 30 Poles upon a Level Line, $\frac{89}{100}$ of a Pole, and then I may account my self distant from the place in the Valley where I made Observation, 30 Poles in a Level or Horizontal Line, and so set down the Distance without a Fraction: the like is to be understood of all other Ascents and Descents.

Here followeth the Table.

	1 d.	89 d.	2 d	88 d	3 d.	87 d.	4 d.	86 d.	5 d.	85 d.
1	300	5	300	10	300	15	299	21	299	26
2	600	10	600	21	600	31	599	42	598	52
3	900	15	900	31	899	46	598	63	896	79
4	1200	20	1200	42	1198	62	1198	84	1195	105
5	1500	26	1500	52	1497	78	1497	105	1494	131
6	1800	31	1799	64	1798	93	1796	126	1794	157
7	2100	37	2099	74	2097	110	2095	148	2093	183
8	2400	42	2398	84	2397	124	2394	168	2391	209
9	2700	47	2698	95	2696	140	2694	189	2690	235
10	3000	52	2998	105	2996	157	299	210	2989	262
1	10	00	10	0	10	0	10	1	10	1
2	20	00	20	1	20	1	20	1	20	2

	6 d.	84 d.	7 d.	83 d.	8 d.	82 d.	9 d.	81 d.	10 d.	30 d.
1	298	31	298	37	297	42	296	47	295	52
2	597	93	596	74	594	84	592	94	590	104
3	095	64	894	111	891	125	889	140	887	156
4	1193	126	1192	146	1188	167	1185	187	1182	208
5	1492	157	1489	183	1485	209	1481	234	1477	260
6	1790	188	1787	220	1782	251	1777	281	1772	312
7	2080	220	2085	257	2080	292	2074	328	2069	365
8	2386	251	2383	292	2377	334	2371	375	2364	417
9	2686	283	2680	329	2674	376	2667	422	2659	469
10	2984	314	2978	366	2971	418	2963	469	2954	521
1	10	1	10	1	10	1	10	1	10	1
2	20	2	20	2	20	3	20	3	20	3

	11 d.	79 d.	12 d.	78 d	13 d.	77 d.	14 d.	76 d.	15 d.	75 d.
1	295	57	293	62	292	67	291	73	290	78
2	590	114	586	124	584	134	582	146	580	156
3	883	172	881	188	876	203	873	219	870	233
4	1178	229	1174	250	1169	270	1164	290	1160	310
5	1473	286	1467	312	1461	337	1455	363	1449	388
6	1768	343	1760	374	1754	404	1746	436	1739	466
7	2060	401	2055	436	2047	472	2038	508	2030	543
8	2355	458	2348	500	2339	540	2329	580	2320	621
9	2650	515	2641	562	2651	608	2620	653	2610	699
10	2945	572	2934	624	2929	675	2911	726	2898	776
1	10	2	10	2	10	2	10	2	10	3
2	19	4	19	4	19	4	19	4	19	5

	16 d.	74 d.	17 d.	73 d.	18 d.	72 d.	19 d.	71 d.	20 d.	70 d.
1	288	83	287	88	285	93	284	98	282	103
2	576	166	574	177	570	186	568	296	564	206
3	865	250	861	264	855	279	851	194	846	308
4	1153	332	1148	352	1140	371	1135	391	1128	411
5	1442	413	1434	438	1426	463	1418	488	1410	513
6	1730	496	1721	526	1711	556	1702	586	1692	616
7	2019	580	2008	615	1997	649	1986	684	1973	719
8	2307	663	2296	703	2282	743	2270	782	2255	822
9	2596	746	2582	791	2567	836	2552	880	2537	924
10	2884	827	2869	877	2853	927	2836	977	2819	1026
1	10	3	10	3	10	3	10	3	10	3
2	20	5	19	6	19	6	15	6	19	6

	21 d	69 d.	22 d	68 d.	23 d	67 d	24 d.	66 d.	25 d.	65 d
1	280	107	278	112	276	117	274	122	272	127
2	560	215	556	224	552	234	548	244	544	254
3	840	322	834	337	828	351	822	366	816	381
4	1120	429	1112	449	1104	468	1096	488	1088	508
5	1400	537	1391	562	1380	586	1370	610	1360	634
6	1680	645	1669	674	1656	703	1644	732	1632	761
7	1960	752	1947	786	1932	820	1918	854	1904	888
8	2240	860	2225	899	2209	937	2192	976	2175	1015
9	2521	968	2504	1011	2485	1054	2466	1098	2447	1142
10	2801	1075	2782	1124	2761	1171	2740	1220	2719	1268
1	9	4	9	4	9	4	9	4	9	4
2	18	7	18	8	18	8	18	8	18	8

	26 d.	64 d.	27 d.	63 d.	28 d.	62 d.	29 d.	61 d.	30 d.	60 d.
1	270	131	267	136	265	141	262	145	260	150
2	540	263	534	272	530	282	524	290	520	300
3	810	394	801	408	795	423	786	435	780	450
4	1079	525	1068	544	1060	564	1048	581	1040	600
5	1348	657	1336	681	1324	704	1312	727	1299	750
6	1618	788	1603	817	1589	845	1574	872	1559	900
7	1888	1919	1870	953	1855	986	1836	1017	1819	1050
8	2157	1050	2138	1089	2120	1127	2098	1162	2079	1200
9	2427	1282	2405	1225	2384	1267	2361	1308	2339	1350
10	2696	1315	2673	1362	2649	1408	2624	1454	2598	1500
1	9	4	9	5	9	5	9	5	9	5
2	18	18	18	10	18	10	18	10	18	10

	31 d.	59 d.	32 d.	58 d.	33 d	57 d	34 d.	56 d.	35 d.	55 d
1	257	154	254	159	252	163	249	168	246	172
2	514	309	508	318	504	326	498	336	492	344
3	773	463	763	477	755	489	747	504	738	516
4	1028	617	1017	636	1007	653	995	671	983	688
5	1285	772	1272	795	1258	817	1243	838	1228	860
6	1542	927	1526	954	1510	980	1492	1006	1474	1032
7	1809	1081	1780	1113	1762	1144	1741	1174	1720	1204
8	2057	1235	2034	1272	2013	1307	1990	1342	1966	1377
9	2314	1390	2288	1431	2265	1470	2238	1510	2212	1549
10	2571	1545	2544	1590	2516	1634	2487	1677	2457	1721
1	9	5	8	5	8	5	8	6	8	6
2	18	10	16	10	16	10	16	12	16	12

	36 d.	54 d.	37 d.	53 d	38 d.	52 d.	39 d.	51 d.	40 d.	50 d
1	243	176	240	180	236	185	233	189	230	193
2	486	352	480	360	472	370	466	378	460	386
3	729	528	720	541	709	555	699	567	690	578
4	971	705	960	721	945	739	932	756	920	771
5	1213	881	1198	902	1182	923	1165	944	1149	964
6	1456	1057	1438	1082	1418	1108	1398	1133	1379	1157
7	1699	1234	1678	1262	1654	1293	1631	1322	1609	1350
8	1942	1410	1918	1443	1890	1479	1865	1511	1839	1543
9	2185	1586	2157	1624	2126	1663	2094	1700	2069	1735
10	2427	1763	2396	1805	2364	1847	2331	1888	2298	1928
1	8	6	8	6	8	6	8	6	8	6
2	16	12	16	12	16	12	16	12	16	12

	41 d.	49 d.	42 d.	48 d	43 d.	47 d.	44 d.	46 d.	45 d.	45 d.
1	226	197	223	201	219	205	216	208	212	212
2	452	394	446	402	438	410	432	416	424	424
3	678	591	669	603	658	614	648	625	636	636
4	905	788	892	803	878	819	864	833	849	849
5	1132	984	1114	1003	1097	1023	1079	1042	1061	1061
6	1358	1181	1337	1204	1316	1228	1295	1250	1273	1273
7	1584	1378	1560	1406	1535	1433	1511	1458	1485	1485
8	1810	1575	1783	1607	1754	1638	1727	1666	1697	1697
9	2036	1772	2006	1807	1974	1842	1943	1874	1910	1910
10	2236	1968	2229	2007	2198	2046	2158	2084	2122	2122
1	8	7	7	7	7	7	7	7	7	7
2	16	14	14	14	14	14	14	14	14	14

The Structure of this Table is from this ground:

As *Radius* is in proportion to the Distance of two places measured in their Rumb; so is the Sine of the Complement of that Rumb, to the Difference in Latitude of these two places.

And so is the Sine of that Rumb, to the Distance of the Meridians of those two places. As, admit I measure South-Easterly 20 *deg.* 300 Poles, here then the Rumb upon which I measure, making with the Meridian an Angle of 20 *deg.* I say,

As *Radius* is in Proportion	
to the Distance measured 300 Poles;	2.47712
So is Sine Complement the Rumb, S E 20 *deg.*	9.97299
to the Difference of Latitude 281 $\frac{21}{100}$ *ferè.*	2.45011

Whereby it appears, that the Distance of the Parallels of these two places is 281 $\frac{21}{100}$ Poles; or that the place whereto I measure, is more Southerly than the place from which I measured, by 281 $\frac{21}{100}$ Poles. Now for the Distance of their Meridians, say,

As *Radius* is in Proportion	
to the distance measured 300 Poles;	2.47712
So is the Sine of the Rumb S E 20 *deg.*	9.53405
to their Distance in Longitude 102 $\frac{606}{1000}$	2.01117

Ch	Poles.
1	28.19
2	56.38
3	84.57
4	112.76
5	140.95
6	169.14
7	197.33
8	225.52
9	253.71
10	281.92

And thus I find the place whereto I measured, is more Easterly than the place from which I measured, by 102 $\frac{6}{10}$ Poles, and somewhat more. And in like sort may be found all the other numbers expressed in this Table; but having thus found for every *degr.* to 45 *degr.* two numbers, the rest may be deduced from them, as in this Example: 300 Poles at three Poles to the Chain, is an 100 Chains, or 10 Changes; finding that in 10 Changes upon this *degr.* the difference Southerly is 281 $\frac{2}{10}$ Poles, it must for 5 Changes, which is just half so much be almost 141; and for one Change, which

which is a tenth part 28 $\frac{3}{10}$ *ferè*, and ſo for two Changes twice ſo much, that is 56 $\frac{6}{10}$, for three Changes thrice ſo much, that is, the ſum of the two former, namely, 84 $\frac{9}{10}$, and ſo by Addition only you may find the reſt, as in this Table, which I ſhall need to proſecute no further. And thus you may make it to the hundredth or thouſand parts of a Pole; but this for ordinary occaſions, for which it was at firſt intended, may ſuffice.

And according to this Example, it will be eaſie to frame the like Table for a Chain of any other ſize, or for any other Meaſure which you uſe.

It may be objected, That howſoever this Rule holds true in plain Triangles, yet the Triangles here uſed are neither Plain nor Spherical; for a Plain Triangle is made of three right Lines, a Spherical of three Arches of great Circles; But in this the three ſides are of three ſeveral kinds; namely, one ſide is an Arch of the Meridian, and ſo of a great Circle; another an Arch of a Parallel, and ſo of a leſſer Circle, the third ſide or *Hypothenuſal* being the Rumb, is no Arch of a Circle, but a Segment of an Heliſpherical Line.

But I anſwer, That notwithſtanding this may be ſpeculatively conceived, and ſo demonſtrated to be no plain Triangle; yet in ſo ſmall Diſtances as theſe which here we uſe, there can be no ſenſible nor ſcarce any numerable difference. Yea, the Diſtance between two Parallels by the Rumb and Diſtance given (being the thing here chiefly aimed at) is very exactly found by this Rule, as before we have ſhewed, and as is more fully demonſtrated by Mr. *Wright*, in the 12*th* Chapter of his Book, *Of the Correction of Errours in Navigation:* Whence we may conclude, that the parts of the Meridian collected by this Table according to the Rumbs and Diſtances, as we have before ſhewed, do give the true meaſure of the Segment of that Meridian intercepted, between the Parallels of the two places propoſed.

CHAP. IV.

Of the difference of Longitude, Position, and Distance of York *and* London: *And how the Maps of* England *may by this Experiment be reformed, especially in the Latitude of Places.*

WE come next to speak of the Easterly and Westerly Distances gathered, as before is shewed by these Tables, and to find thereby the difference of Longitude; and of this we will give an example in the foresaid Experiment; whereby we find that the distance in Longitude, or the East and West Distance between *York* and *London*, is near 14000 Poles, *London* being so much more Easterly than *York*. And before we have found that in a *degr.* of the Meridian, and consequently in a *degr.* of the Equinoctial, there is near 3709 $\frac{1}{10}$ Chains, at 6 Poles to the Chain, and this 14000 Poles converted into such Chains, is 2333 $\frac{1}{3}$.

Which 2333 $\frac{1}{3}$ Chains (for finding the difference of Longitude) are not to be reckoned in the Parallel of *York*, that being too much Northerly; neither in the Parallel of *London*, being too much Southerly, but in a middle Parallel between both; namely, about the Latitude of 52 *degr.* 45 *min.* Now to find what difference of Longitude is answerable to this 2333 $\frac{1}{3}$ Chains in the Parallel of 52 *degr.* 45 *min.* say,

As *Radius* is in proportion
to Sine Complement the Latit. *sc.* 52 *deg.* 45 *min.* 9.78197
So is the measure of a *deg.* in the Equinoctial 3709 $\frac{1}{10}$ 3.56927
to the measure of a *deg.* in that Parallel 2245 $\frac{1}{10}$ 3.35124

And

And thus we find that in the Parallel, whose Latitude is 52 *degr.* 45 *min.* there are 2245$\frac{1}{19}$ Chains answering to a *degr.* whereby it appears that the difference of Longitude between *York* and *London*, is more than one *degr.* and to find how much more, say again by the Rule of Proportion:

As the measure of a *degr.* 2245 $\frac{1}{10}$ *Co. ar.*	6.64876
is to a *degr.* in *Seconds*, 3600	3.55630
So is the measure given, 2333 $\frac{1}{3}$	3.36797
to the number of *Seconds*, 3741	3.57303

Which reduced, is 1 *degr.* 2 *min.* 21 *seconds*; and thus we find that *London* doth differ in Longitude from *York* 1 *degr.* 2 *min.* 21 *seconds*, being so much more Easterly.

Thus having the difference of Latitude, as also the difference of Longitude between these two places, we may (according to the Second Problem of Sailing by *Mercators Chart*) find the Rumb from *London* to *York* to be 14 *degr.* 20 *min.* from the North to the Westwards; that is, North and by West 3 *degr.* 5 *min.* Westerly, and the distance in that Rumb 9442 Chains. But their distance in the High-way, by reason of the crookedness and un-evenness of it, was more by about an eighth part.

And the like might be done for other intermediate Places between these, but affecting brevity, we pass that over, as not much pertinent to our present purpose; only expressing the Latitudes of some of the principal of them, as followeth.

	Latitudes.			
As the Latitude of *York*, we find to be	53	*deg.*	58	*min.*
Doncaster	53	*deg.*	32	*min.*
Newark upon *Trent*	53	*deg.*	5	*min.*
Grantham	52	*deg.*	54	*min.*
Stamford	52	*deg.*	38	*min.*
Huntington	52	*deg.*	19	*min.*
Royston	52	*deg.*	3	*min.*
Ware	51	*deg.*	48	*min.*
London	51	*deg.*	30	*min.*

We

We further noted in this Experiment, that howſoever the number of Miles between *Ware* and *London*, are almoſt the ſame by eſtimation that they are by meaſure; yet all the way beſides from *York* to *Ware*, a meaſured Mile conſiſting of 320 Poles, is but three quarters of a Mile, as the Miles lie by Eſtimation or common account; ſo that every where (for the moſt part) three Miles by eſtimation make 4 meaſured Miles: and a *min.* or the 60th part of a *deg.* is almoſt in the middle betweeen them both: So that look how much a meaſured Mile is leſs than a *min.* ſo much, or ſomewhat more is a Mile by eſtimation greater than a *min.* for as there is contained in a *degr.* of meaſured Miles 69 $\frac{1}{2}$ and ſomewhat more, as we have before ſhewed; ſo of our common eſtimated Miles, there are contained about 51 $\frac{3}{4}$ in a *deg.*

Upon theſe Grounds the whole Maps of this Kingdom might be much rectified, eſpecially in the Latitude of Places; for though we cannot hence determine certainly the Latitudes of any other places beſides thoſe which were in the way, or at leaſt in ſight as we came up (the principal of which we have before noted.) Yet we may nearly conjecture the Latitudes of moſt parts of *England*, by their Diſtances and Poſitions from theſe; but theſe things being beſides our ſcope and purpoſe in this place, we ſhall only compare the Latitude of ſome principal places, probably gathered from this Experiment, with the Latitudes of the ſame places, as they are ſet down by Mr *Speed* in his *Geographical* Deſcriptions of *England*; that ſuch as pleaſe to examine both in any particulars, may know to which they may more ſafely lean.

Canterbury

	Latitud. by this Exper.		Latitud. by Mr. *Sp.* Map.	
	D.	M.	D.	M.
Canterbury	51	17	51	29
Chicheſter	50	48	50	51
Guildford	51	12	51	52
Wincheſter	51	03	51	11
Dorcheſter	50	40	50	44
Exceſter	50	43	50	48
Wells	51	12	51	22
Salisbury	51	04	51	12
Redding	51	28	51	42
London	51	30	51	45
Colcheſter	51	58	52	16
Ipſwich	52	08	52	30
Norwich	52	42	52	10
Cambridge	52	12	52	32
Hertford	52	49	52	06
Bedford	52	08	52	30
Buckingham	52	00	52	20
Royſton	52	04	52	24
Oxford	51	46	52	02
Gloceſter	51	53	52	12
Hereford	52	07	52	27
Worceſter	52	14	52	36
Warwick	52	20	52	45

	Latitude by this Exper.		Latitude by Mr. *Sp.* Map.	
	D.	M.	D.	M.
Northampton	52	14	52	36
Huntington	52	19	52	44
Stamford	52	38	53	04
Leiceſter	52	40	53	05
Lincoln	53	14	53	50
Newark upon *Trent.*	53	05	53	38
Nottingham	53	00	53	32
Derby	52	58	53	30
Stafford	52	52	53	22
Shrewsbury	52	47	53	16
Cheſter	53	16	53	52
Lancaſter	54	10	54	57
York	53	58	54	44
Richmond in *Yorkſhire*	54	28	55	18
Kingſton upon *Hull*	53	48	54	29
Doncaſter	53	32	54	12
Durham	54	50	55	45
Carlile	55	00	55	56
Newcaſtle	55	03	56	01
Barwick	55	54	57	03

The Latitudes of these places in the first Column expressed, are such as are probably gathered from this Experiment. But in the second Column there is set down the Latitudes of the same places, as they are expressed by Mr *John Speed* in his Map of *England*, set forth in his Book, Entituled, *The Theatre of the Empire of* Great Britain; and lest there should be any mistake in his Map, I have conferred these Latitudes thence gathered, with the Latitudes of the same places, set down by him in words at large, in his Descriptions of each several County, and find them nearly to agree, except in the Latitude of *Barwick*, which in his Map he makes to be 57 *degr.* 3 *min.* But in his Historical Descriptions of *Northumberland*, he relates it to be 55 *degr.* 48 *min.* which last is much nearer the truth, but seems not to be his meaning; because then he should make it more Southerly than *Newcastle*, yea, more Southerly than he doth *Carlile*, which by his Map, and also by his words in his Relation of *Cumberland*, is in the Latitude of 55 *deg.* 56 *min.* whereas *Barwick* is above 50 miles more Northerly.

By these you may nearly conjecture the Latitudes of other parts of *England*, lying in or near the same Parallel with any of them: And hence also it appears, that the difference of Latitude between *Barwick*, and the South Coast of *England* near *Christ-Church*, is little more than 5 *degr.* not 6 *degr.* and more, as some of our Maps make it. But these things we must leave, that we may proceed to that which is principally intended, only we will first touch a little upon the use of the fore-going Table, in plotting and surveying of Land.

CHAP.

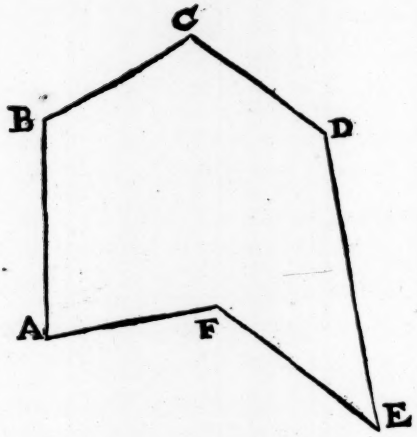
CHAP. V.

To Delineate the Plot of any Forrest, Park, Common, or other pieces of Ground: as also of Rivers, Harbours, &c. *speedily and most exactly.*

MY intent is not here to prosecute at large the Plotting of Grounds, being a thing handled by others, treating of *Surveying:* But considering that the ways by them directed, and by others practised, in delineating or laying down the Distances and Angles observed by the *Circumferentor*, *Theodolite*, *Peractor*, or other graduated instrument, is by a *Protractor*, and that the Table before going, or that which followeth towards the end of this Treatise, serveth for that and the like purposes, almost as speedily, and far more exactly; I shall crave leave to digress a little to shew this Use of it as briefly as I may. Therefore passing over the method to be used in setting down the Names of the Grounds, the Tenants, Borderers, and other remarkable things, and leaving every man in these to the ways whereunto he is accustomed; You may (as sometimes I do) make a Book in a long *Octavo*, and upon the left side thereof set down such things, as these before mentioned, reserving every right side, and dividing them by Ruled Lines into 6 Columns; as hereafter following appeareth.

And having taken and set down your Notes in the Field on the left sides or Pages of your Book, you may in the Evening or next morning before you go out, or when else your occasions will permit, set down in the first Columns on the right side, how many *degr.* the Lines upon which you have Traversed, are distant from the North or South part of the Meridian towards the East or West, and in the second Columns the quantity of the same Lines, in Changes, Chains, and single Poles, and parts of Poles.

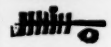
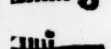
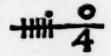
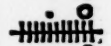
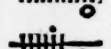
As in this Figure; ſuppoſe the Line from *A* to *B* to be directly Eaſt, 7 Changes, that is, 7 times 30 Poles, or 210 Poles, From *B* to *C* to the Eaſtwards of the South 35 *degr.* 5 Changes, and 1 Chain, from *C* to *D*, to the Weſtwards of the South 32 *degr.* 5 Changes, and 4 Chains, from *D* to *E* to the Weſtwards



of the South 80 *degr.* 10 Changes, from *E* to *F*, to the Eaſtwards of the North 35 *degr.* 6 Changes, 3 Chains, and two thirds of a Pole. And laſtly, from *F* to *A*, the place where I firſt began, to the Weſtwards of the North 9 *degr.* 5 Changes, 3 Chains, 2 ½ Poles: All theſe I expreſs in the firſt and ſecond Columns on the right ſide, as hereafter following appeareth.

Which done, I take the Table, and find there the Northing and Southing, Eaſting or Weſting anſwering to theſe *degr.* and Diſtances, and ſet them down accordingly. As for the firſt being Eaſt 7 Changes, I ſet down in the Eaſt Column 210 Poles with

with a Cypher behind it. For the ſecond being *S E*, 35 *degr.* I find in the Table for 5 Changes 1228, to be ſet in the South Column, and 860 for the Eaſt Column, alſo upon the ſame *degr.* for 1 Chain 25 for the South Column, and 17 for the Eaſt Column, and ſo I proceed with all the reſt, until I have finiſhed.

	Deg.		*Diſtance.*	*North.*	*South.*	*Eaſt.*	*Weſt.*
	Eaſt.					2100	
	S E	35			1228 0025	0860 0017	
	S W	32			1272 0102		0795 0064
5	*S W*	80			0521		2954
6	*N E*	35		1474 0074 0005		1032 0052 0004	
7	*N W*	09		1481 0089 0025			0234 0014 0004
				3148	3148	4065	4065

And being thus returned to my firſt Station, I ſum up ſeverally theſe four Columns of North, South, Eaſt and Weſt; and finding that the ſum of the North Column is equal to that of the South, and the ſum of the Eaſt is equal to that of the Weſt, I conclude the whole Work to be truly performed; whereas if there had been any difference, it had ſhewed an Errour; and if that difference had been great, it had been neceſſary to examine the Work again, and ſo to correct it.

It is usual to add together all the Angles, and also to multiply two right Angles, or 180 *degr.* by the number of Angles lacking two; and if the sum of the Angles added together, be equal to this Product, the Work is thought to be true: as here, if we add the Inclinations and Reclinations of these Lines in this Figure, the Sum is 720 *degr.* or 8 right Angles; and if we multiply two right Angles by 4, (because here are 6 Angles) the Product is also 8 right Angles. But the other by the Sums of the Columns, is a most absolute way for examining the truth of your Work, and to be preferred before any other that I know.

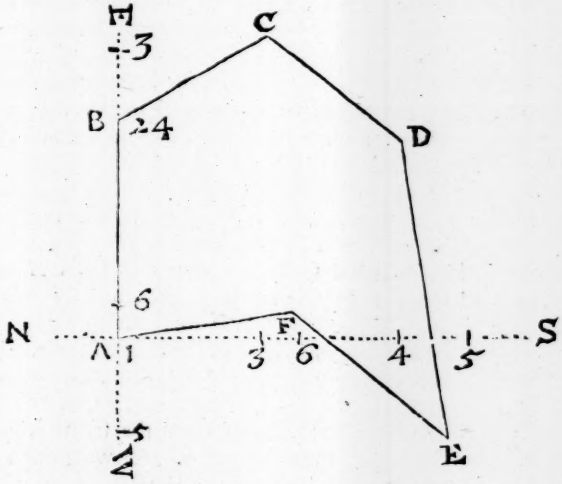
It may seem very laborious to set down every Station in this manner, but one that is a little exercised in it may, as I take it (for I never observed the time exactly) set down 40 or 50 Stations in this manner, within the space of an hour, or thereabouts: But I should advise that it be done by two Men, having each a Table for that purpose, to avoid all mistakes.

If your Instrument give not the Angle with the Meridian expresly, yet it may easily be gathered thence, or else you may divide a Circle as your Instrument is divided, and number the *degr.* as they are there numbred; which done, number them also from the N. and S. part of the Meridian towards the E. and W. so shall you easily know the Angle of any *deg* with the Merid.

Now to proceed, these measures may be set down in a Plot several ways. As first, considering which way the Ground lies, I take a Point for my first Station, so as the whole may fall conveniently within the Plot, which let be the Point *A*, by which Point I draw a Meridian and Parallel, namely two right Lines intersecting one another at right Angles: whereof let *N S* be the Meridian running North and South, and *E W* the Parallel running East and West; this done, I look to the North and South Columns, and the first in the South Column, and against the third Station, I find 1 2 5 5, that is, 1 2 5 $\frac{5}{10}$ Poles, this I set in the Meridian from *A* to the Southwards, and mark the Point with the Figure 3; then in the South Column against the fourth Station, I find 1 3 7 4, which I set in the Meridian from 3 to 4; also against the first Station I find 5 2 1, which I set in the Meri-

5 dian.

dian from 4 to 5. Then againſt the ſixth Station, I find in the North Column 1 5 5 3, which I ſet in the Meridian from 5 to 6: alſo againſt the Seventh Station, which is the ſame with the Firſt, I find 1 5 9 5, which I ſet in the Meridian from 6, and it falls upon *A*, which is the firſt Station: and thus have I done with the South and North Columns.



In like ſort I expreſs the meaſures in the Eaſt and Weſt Columns in the Parallel *E W.* As finding firſt in the Eaſt Column 2 1 0 0, I ſet it down from *A* to the Eaſtwards, and it extends to *B*, where I ſet 2, ſignifying my ſecond Station; I find next in the Eaſt Column 877, which I ſet in that Parallel from 2 to 3, next in the Weſt Column 8 5 9, which I ſet in that Parallel from 3 to 4: and ſo I proceed with the reſt. And having thus ſet down the Meaſures in the Meridian and Parallel, we have alſo as it falls out in this Example, two Stations expreſs'd, namely *A* and B, now

now for the third, I take in the Parallel with my Compasses the distance *A* 3, and setting one Foot in the Meridian at 3, I strike an Arch near *C*; also taking in the Meridian the Distance *A* 3, and fixing one Foot in the Parallel at 3, I cross the foresaid Arch near *C*; the intersection of these two Arches is the Point *C*, representing the third Station.

In like sort, I proceed to find the Points *D E F* for the fourth, fifth and sixth Stations, then drawing Lines, namely, from the first Station *A* to the second *B*, and from the second to the third *C*, &c. We shall describe the Figure required, *A B C D E F*.

Otherwise whereas here you Add and Substract the several Distances of South and North, as also of East and West by your Compasses, you may with a little more pains Add and Substract them by the Pen, which is the better way.

As having set down in the Meridian the Southerly distance of the third Station 1253, I add thereto 1374, which is against the fourth Station, the sum is 2627; the Southerly distance of the fourth Station, which I set in the Meridian from *A* to 4. Again, to this I add 521, so have I 3148, the Southerly distance of the fifth Station A 5, from which substracting 1553, the Northerly distance set against the sixth Station, there remains 1595, which is the Southerly distance of the sixth Station, to be set in the Meridian from *A* to 6. Lastly, from this, abating the Northerly distance of the first Station from the sixth, which I find there also to be 1595, there remains 0. Shewing that I am returned to the same Parallel, or East and West Line, in which at first I began. And in like sort, you may proceeed with the East and West Columns, and then by the intersection of two two Arches, find every Station as before.

Other ways might be prescribed, which will not be hard to find of your self. And as we may thus lay down any irregular right-lined Figure far more exactly than by the *Protracter*: So when it is laid down after this manner, we may cast up the *Area* or superficial quantity of it very exquisitely: Yea, if there should be a Plot drawn (according to the Angles and Distances herein given) after the usual manner, by a Scale so large, that the

Plot

Plot ſhould be an hundred rimes ſo great as this; yet could not the Content thereof be caſt up ſo exactly and certainly as it may be here.

But I muſt not inſiſt upon theſe things, they may of themſelves be conceived, and my intent is only to touch them, that I be not prevented of time, and by other occaſions from handling thoſe things which I have here more ſpecially intended.

But as I have ſaid, this courſe is chiefly to be uſed in Plotting large Grounds, and there indeed are graduated Inſtruments, eſpecially to be uſed for other ſmaller grounds; there is none more fit than the *Plain Table.*

CHAP. VI.

Of the Compaſs of the Earth, and the quantity of a Degree, according to the moſt approved Experiments Ancient and Modern.

ALthough the Compaſs of the Earth hath been in ſome ſort obſerved by divers of the Ancients: Yet for ſome of them we cannot certainly gather what meaſures they uſed; others uſed no meaſure at all, but aſſumed the Diſtance of places to be ſuch as it was eſtimated by Travellers to be, and likewiſe the Latitude; therefore it will be needleſs to inſiſt upon the examination of their Obſervations; others of them which were taken by meaſure, and which we may upon any good ground reduce to our meaſures, are theſe which follow.

Willebrordus Snellius in his Book Entituled *Eratoſthenes Batavus*, cites *Abel Fedai*, a moſt diligent *Arabian* Geographer, that lived about the year of Chriſt 1322, who records, that about

about the year of Christ 827, certain Men skilfull in the *Mathematicks*, did by the commandment of their Prince *Almanon*, measure in the Fields of *Mesopotamia* (as he gathers) under one and the same Meridian, from the North towards the South, the quantity of a *degr.* and found it to be 56 Miles, or somewhat more. The quantity of their Mile, according to *Alphragranus*, was 4000 Cubits, or 6000 Feet, whence the quantity of a *degr.* should be 336000 Feet; but of the length of their Feet we are something uncertain; only they define it to be so long as the extent of 96 Barley Cowns laid side by side; whereas the *Rhynland* Foot, according to tryal by him made, is but the extent of 90 Corns laid in like manner, so that if there be no inequality in the Grains, then 90 *Arabian* Feet are equal to 96 *Rhynland*-Feet. But 96 *Rhynland*-Feet are found to be about 91 $\frac{1}{6}$ *English* Feet; therefore also by the Rule of Proportion, 336000 *Arabian*-Feet do make of our *English* Feet 370222. So that according to this Experiment of the *Arabians*, a *degr.* should contain 370222 of our *English*-Feet. And before we have found by the Observations taken at *London* and *York*, and by the distance of the Parallels measured, that a *degr.* contains of our *English*-Feet 367200. The difference is only 3022 Feet, that is, about the $\frac{1}{120}$ part of a *degr.* or half a *min.*

He cites next *Alhazen* the *Arabian*, who in his Book *de Crepusculis*, declares the Compass of the Earth to be 24000000 Paces; so that Proportionally there must be in one *degr.* 66666$\frac{2}{3}$ Paces, that is 333333 *Arabian*-Feet. And seeing that 90 *Arabian*-Feet make of our *English*-Feet 99$\frac{1}{6}$, therefore by the Rule of Proportion 333333 *Arabian*-Feet, make of our *English*-Feet 367283: So that according to *Alhazen*, there should be in a *degr.* 367283 of our *English*-Feet, differing from the Experiment which I made only 83 Feet in a *degr.*

I have not strained these numbers to bring them to this nearness, they are the same in effect which are set down by *Snellius* in his *Eratosthenes Batavus*, who with great Industry and Judgement hath compared the measures of the Ancients, and the measures used by several Nations in these times, with the

Rhyn-

Rhynland-Foot. Much leſs have I ſtrained my own numbers to draw them up to theſe: But on the contrary, I confeſs upon the ſight of his Book, obſerving the great pains and induſtry which he profeſſeth himſelf to have beſtowed, and which I doubt not but he did imploy in making his Experiment, and how he had found the meaſure of a *degr.* to be much leſs than mine, as we ſhall after ſhew, I began to doubt that I had not made ſufficient allowance for the un-evenneſs of the ways, and for ſome ſmall bendings, ſometimes to the right hand, ſometimes to the left, the Obſervation whereof I wittingly neglected, to ſpare time and Expence. For I did often obſerve a Mile or two before me, ſome Mark in the High way noting the *degr.* and meaſuring to it in the way, neglecting to obſerve the intermediate ſwerving of the way, ſometimes three or four *degr.* towards the right hand, ſometimes as much to the left; but making ſuch allowance for that, and for the un-evenneſs as I judged ſufficient. And ſome men may think, that the exact Obſervation of theſe leſſer things thus neglected, and regulated only by judgement or conjecture, might deceive me much: But they may conſider, that if there be two places a Mild diſtant, that is, in a right Line 320 Poles, if you meaſure from one of theſe places towards the other, not in that right Line, but always ſwerving from it by an angle of four *degr.* ſometimes to the right hand, ſometimes to the left, till you come to that other place; I ſay, that notwithſtanding all theſe ſwervings (if there be nothing elſe to augment the meaſure) it will not amount to 321. Now conſidering that I had all the way, as occaſion required, made ſuch allowance as ſeemed convenient, and ſo found 367200 Feet in a *degr.* before I compared it with the meaſures taken by another: I reſolved not to diminiſh nor to augmeut the numbers thus ariſing by my Obſervations, Meaſures, and allowances, in reſpect of the Opinions, Obſervations, or Meaſures of any other Man, until there be made ſome Experiment more evident and exact than any yet extant. And I am ſomething the more confirmed by the near agreement of theſe two teſtimonies before recited, both exceeding me a little in the meaſure of a *deg.* But we cannot confi-

dently reſt upon them, becauſe of that inequality which may be of Corns or Grains; for theirs may haply be ſomething greater or leſſer than ours.

Both theſe meaſures of a *degr.* do much exceed the quantity of a *degr.* found by *Snellius*, but when he compares them with his own another way, namely, placing the Barley-Corns ſo that they may not lie flat, but be ſet up edge-wiſe, and ſo by 96 Corns to make a Foot, and by ſuch Feet to meaſure a *degree*; then he finds that the quantity of a *Degree*, according to the *Arabians*, is much leſs than by his Experiment it ſhould be: but if ſome be laid flat, and others ſet up edge-wiſe, the *Arabian* meaſure of a *degr* will agree with his. And ſo he propoſeth this doubt, whether the 96 Grains, whereof the *Arabian* Foot doth conſiſt, muſt lie flat or be ſet up edge-wiſe, or ſome of them to lie flat, and others to be ſet up edge-wiſe. But it is moſt probable that they muſt lie flat, that being the poſition which they are apt unto by nature; they cannot be ſet edge-wiſe without much trouble, eſpecially ſo many together as make the length of a Foot, and ſo the *Arabian* meaſure of a *degr.* doth near agree to this of mine.

We come next to hear the determination of *Ptolomy* of *Alexandria*, whoſe authority and credit in the ſolution of this queſtion, is not inferiour to any of the Ancients. He affirms the Compaſs of the Earth to be 180000 *Stadiums*, and the quantity of a *degree* 500 *Stadiums*; the ſame (as *Strabo* ſaith in his ſecond Book of *Geography*) was before affirmed by *Poſidonius*. Alſo *Martinus Tyrius* (before *Ptolomy*) had determined the quantity of a *degr.* to be 500 *Stadiums*. *Ptolomy* confirms it, not ſimply from their relations, but as it ſeems from his own experience, and that by ſome meaſures diligently taken, for in the 11 Chap. of the firſt Book of his *Geography*, he hath theſe words; *Sed in hoc quoque recte ſentit, partem unam qualiam eſt circulus maximus tricentorum ſexaginta; quingenta in terra conſtituere Stadia, id enim confeſſis dimenſionibus conſonum exiſtit.* Alſo *lib.* 7. *cap.* 5. *Ita ut pars una, ſeu gradus unus quingenta contineat Stadia, quemadmodum ex diligentibus deprehenſum eſt dimenſionibus.*

Now

Now a *Stadium* not only among the *Greeks*, but as appears by *Herodotus* amongſt all other Nations of *Aſia* and in *Ægypt*, did conſiſt of 600 Foot; therefore a *Degree* according to *Ptolomy*, muſt contain 300000 Feet. But the *Ægyptian* or *Alexandrian* Foot was much greater than our Foot; for as we have before ſaid, the ancient *Roman* Foot is greater than ours, and the *Ægyptian* Foot was much greater than the *Roman*: For it is often teſtifyed by *Hero Merchanicus*, that 5 *Alexandrian*-Feet make 6 *Roman*-Feet. And Mr. *Snellius* hath very ingeniouſly gathered both from *Philandes* and otherwiſe, that the *Rhynland*-Foot is equal to the ancient *Roman*-Foot; therefore alſo 5 *Alexandrian* Feet are equal to 6 *Rhynland Feet*: So that by the rule of Proportion, 300000 *Alexandrian* Feet, will make of *Rhynland*-Feet 360000. But by the ſize of our *Engliſh*-Foot, which was ſent him from the Iron Standard in *Guild-Hall*, he finds it to contain but 968 ſuch parts as the *Rhynland* contains 1000: So that 968 *Rhynland*-Feet are equal to 1000 *Engliſh*, or 121 *Rhynland* Feet are equal to 125 *Engliſh*-Feet. Therefore alſo by the Rule of Proportion, 360000 *Rhynland* Feet are equal to 371900 of our *Engliſh*-Feet. Therefore according to *Ptolomy*, there are contained in a *degree* 371900 of our *Engliſh* Feet. But by our fore-mentioned Experiment made between *York* and *London*, we find only 367200 Feet in a *degree*, being leſs than *Ptolomies* by 4700 Feet, that is, by $\frac{1}{80}$ part of a *degr.* or $\frac{1}{4}$ of a *min.* and little more.

Fernelius a Modern Author and Learned Phyſician, meaſuring the way by Revolutions of a Wheel, and the Latitudes by Obſervation, finds in a *degr.* 68 *Italian* Miles, and 96 Paces, the Pace which he uſed being more than 5 of our *Engliſh*-Feet: But becauſe he handled not the Problem exactly, and is ſuſpected by *Snellius* (though I think without cauſe) to have grounded his Concluſion rather upon the Experiment of the *Arabians* before ſet down (wherewith it doth nearly agree) than upon his own, we will inſiſt no longer upon it.

We come in the laſt place to the Experiment of *Willebrordus Snellius*, a *Hollander*, made in the *Netherlands* about 20 years

paſt. We ſhall not need to recite the particulars of it, being extant at large in his Book before mentioned: but in concluſion, he finds in a *degr.* 342000 *Rhynland*-Feet. Now a *Rhynland*-Foot (as he hath there ſhewed, comparing both together) is greater than ours, and that in ſuch Proportion, as 1000 is to 968, (and ſo much or little more it appears to be by that model of the *Rhynland*-Foot Printed in his Book) therefore 968 *Rhynland*-Feet muſt make 1000 of ours; and hence by the rule of Proportion, 342000 *Rhynland* Feet, will make of our *Engliſh* Feet 353306. So that there ſhould be in a *degr.* only 353306 Feet, which is leſs than we have before found in a *degr.* by 13894 Feet, that is, by $\frac{1}{10}$ part of a *degr.* or $2\frac{1}{4}$ *min.* and ſomething more. He was a man doubtleſs of ſingular Induſtry and Knowledge, and of much exerciſe in the *Mathematicks*, and it may be was well experienced in this particular, touching the *Geometrical* menſuration of Diſtances, and he hath beſtowed much pains and diligence in this Experiment, as by his Book appeareth. But if he had by a Chain meaſured the Diſtance of his two utmoſt Stations (if the ground would permit, which I ſuppoſe it would not) or at leaſt-wiſe if his meaſured Stations had been further diſtant; I conceive he would have found a greater Diſtance in his two utmoſt places of Obſervation. But if a man, intending to find the diſtance of two places, meaſure only the $\frac{1}{100}$ part of that Diſtance, and by that meaſured Line and the Angles, think to find their true Diſtance; whether he do it immediately from thoſe two meaſured Stations, or immediately by help of others obſerved from them, he may eaſily fall into ſome notable Errour. For though the Problem be exactly true in Geometrical Demonſtrations, how ſmall ſoever the meaſure be, yet it is not ſo in ſenſible and experimental Practices, by reaſon of the weakneſs even of the beſt Eye, and the imperfection of the Inſtruments in themſelves, and in their uſe. And beſides that there were many Stations obliquely ſituate; a man cannot always hit the juſt middle of that Turret, Steeple, or other mark which he obſerves: neither when he comes to make his Station there, can he always place his Inſtrument juſt at the concourſe of his former viſual Lines, by reaſon of other Impediments. Beſides the force of the wind

wind in ſuch eminent places: and moreover, that amongſt ſo many Steeples as there are in ſome Towns, there, a man may at ſome time miſtake one for another. And if there ſhould happen no notable Errour, by reaſon of any or of all theſe Caſualties: Yet may two *min.* in the difference of the Latitude of two places be eaſily miſtaken, eſpecially being derived from the Latitudes of thoſe places which are very rarely ſet down true to a *min.*

If it be objected, that I might as well be ſo much miſtaken in the difference of the Latitudes of *York* and *London*.

I anſwer, it is not ſo likely, becauſe I had the opportunity of obſerving the Summer Solſtitial Al. of the Sun in both places, wherein I had no neceſſary uſe of the Suns Parallax nor Refraction, nor of the Table of the Suns Declination, any of which may cauſe more than a *min.* Errour, in finding the Latitude of either place.

Beſides, if mine Errour in thoſe Obſervations ſhould be full as much, yet would it not in the Concluſion be half ſo much, becauſe the difference in Latitude of the two places of my Obſervation is more than twice ſo much as that of his.

[*About the Year* 1672, *Mounſieur* Picart *has Publiſhed an Account in* French, *concerning the meaſure of the Earth, a breviate whereof may be ſeen in the* Philoſophical Tranſactions, Num. 112. *wherein he concludes one* Deg. *to contain* 365184 Engliſh-*Feet nearly agreeing to Mr.* Norwood's *Experiment.*]

But let this ſuffice, leaving every man to embrace that which he ſhall beſt approve. Both our Experiments do ſufficiently convince that common Errour of counting only 300000 *Engliſh*-Feet to a *degr.* beſides the conſent of other Obſervations before recited Ancient and Modern.

M. *Snellius* hath further in that Book of his, Entituled *Eratoſthenes Batavus*, with much diligence compared ſome Ancient meaſure, as alſo the meaſures of ſundry Foreign Countreys with the *Rhynland*-Foot; and amongſt the reſt, our *Engliſh*-Foot, according to a ſize thereof to him ſent from the *Standard* in *Guild-Hall*, (from whence alſo I had about 20 years paſt, the ſize of that Foot, which I have uſed in this meaſure,) we ſhall not need to repeat them all, becauſe his Book is extant: Some of them are theſe following, which we here compared to our *Engliſh*-Foot, as he hath there done to the *Rhynland*, that ſo any of them may be the more eaſily reduced into our Feet. Therefore dividing the

the *Engliſh*-Foot into a 1000 equal parts, we ſhew how many of thoſe parts are contained in other Ancient and Forreign Feet.

Ancient Feet compared with our *Engliſh*-Foot.

Of ſuch parts as the *Engliſh*-Foot contains.		1000
The	Ancient *Roman*-Foot contained	1033
	Ancient *Greek*-Foot contains	1076
	Babylonian contains	1211
	Alexandrian contains	1240
	Antiochean contains	1405
	Arabian contains	1102

Foreign Feet compared with our *Engliſh*.

Of ſuch parts as the *Engliſh*-Foot contains.		1000
The	*Rhynland*-Foot contains	1033
	Dort-Foot contains	1085
	Middlebrough Foot contains	992
	Amſterdam-Foot contains	934
	Antwerp-Foot contains	939
	Lovain-Foot contains	939
	Hafnian-Foot in *Denmark*	965
	Paris Foot called the *Kings*-Foot	1090
	Venice-Foot	1157
	Toledo-Foot	896
	Nurimberg-Foot	1006
	Straitsburg-Foot	920

CHAP. VII.

Of dividing the Log-line, *and reckoning the Ships way.*

THere be four things, upon which the Practice of *Navigation* is eſpecially grounded; namely, the knowledge of the Longitude, Latitude, Courſe, and Diſtance. Touching the Longitude, though it may be found by the other

other three, yet hitherto there hath not been delivered any general Rule true and practicable, whereby the Longitudes or places might be immediately and ordinarily found of themſelves. The Latitude of places may immediately be found by Obſervation of the Sun and Stars; as we have formerly ſhewed in the Appendix to the *Doctrine of Triangles:* The Courſe by the Compaſs, the Variation being duly obſerved, wherein we have many good Mariners very expert, this we have alſo handled in the *Doctrine of Spherical Triangles.* The Diſtance run is found of it ſelf by the *Log-line*, whereof we are here to ſpeak.

The ground of finding the Diſtance run by the *Log-line* is meerly conjectural, being founded upon this Opinion, that 5 of our Feet make a Pace, and 1000 ſuch Paces make a Mile, and that 60 ſuch Miles make a *Degree*; ſo that a *Degree* ſhould contain 300000 of our Feet: But it appears not only by this Experiment, but even by all others that were diligently taken, and their meaſures to us known, that there is a greater number of our Feet contained in a *Degree.*

There be three things (as I conceive) that have cauſed this Errour to be ſo commonly received and tollerated. The one, for that it doth ſomewhat counterpoiſe another contrary Errour in the Practice of *Navigation:* namely, in the uſe of the *Plain Chart*; for the Errour which is there committed by making every Parallel equal to the Equinoctial, and ſo every *Degree* in them greater than they ſhould be, is ſomething moderated by this Errour; whereby the meaſure of a *Degree* is eſteemed leſs than indeed it is.

For Inſtance; It is evident by the *Globe*, that the Meridians concurring in the Poles grow nearer and nearer together, as they grow towards the Poles; Inſomuch, as if two Meridians be diſtant in the Equinoctial 10 *Degrees*, that is 600 Miles, the ſame Meridians in the Latitude of 35 *Degr.* will be diſtant little more than 490 Miles. Now if unto every Mile we account according to the former Experiment 6120 Feet, then is the diſtance of thoſe two Meridians in that Parallel near 3000000 Feet. In like ſort in the *Plain Chart* 10 *deg.* of that Parallel (as of all others) is made

equal

equal to 10 *degr.* of the Equinoctial or Meridian: ſo that the Diſtance of theſe two Meridians will upon the *Plain Chart* be 600 Miles, but one of theſe Miles contains only 5000 Feet, ſo that the Diſtance is but 3000000 Feet, equal to the former.

And although theſe Errors in other caſes do not juſtly ballance one another, as in this Example, yet that of the *Plain Chart* is always ſomething moderated by this other, and ſo much the more by how much they are nearer to the foreſaid Latitude. I grant that this is only ſo when the Courſe is near unto the Eaſt or Weſt Points; but withal, I ſay that this kind of reckoning is (in a manner) then only uſed: For he that runs any Courſe near the Meridian Southerly or Northerly, hath a more certain way of reckoning, namely his Latitude, which he finds daily by Obſervation of the Sun and Stars, upon which he will depend, either neglecting, or at leaſt not regarding his dead reckoning. Yea, (if it may be) never caſting the *Log* ſo much as once in ſuch a Voyage, having a more ſure ground for his reckoning. But in a Courſe that is near the Eaſt and Weſt (foraſmuch as there is no way diſcovered for finding the Longitude) he is driven of neceſſity to make uſe of his dead reckoning.

We might add moreover, that the principal Voyages of this kind, I mean of thoſe which conſiſt of Courſes much Eaſterly and Weſterly, as to and from the *Weſt-Indies*, and the Parallel of *Cape bon Eſperance* are near unto this Latitude of 35 *degr.* ſo that as ſome of them are more Southerly, others of them are more Northerly.

But to inſiſt no longer upon this, I ſuppoſe a ſecond cauſe to be, for that Men commonly deſire to have their reckoning before their Ship (as they ſay) that they fall not with a place before they look for it; And this comes ſo to paſs, whilſt the Miles are accounted leſs in meaſure, and ſo more in number than they are indeed.

And thus, though there may ſeem to be ſome commodity in theſe Errours, eſpecially when they do nearly ballance one another: Yet becauſe they ſeldom do ſo, but always leave men in uncertainties, and oftentimes in great perplexity and danger, it

is much safer and better to reject them both, and to embrace those ways, which are evidently grounded upon truth, though there may be in them some more difficult at the first. Yet I confess, that he which reforms one and not another, may sometimes erre so much the more thereby. And I doubt not, but many would reform them both, if they could certainly do so.

Therefore a third cause of admitting and retaining this Errour seems to be, for that there hath been no way delivered from evident and certain Grounds for the rectifying of it. I doubt not but many have found Errours in their Reckonings arising from hence, that they account only 300000 of our Feet to a *Degree*; but not knowing certainly where to lay the fault, have imputed it sometimes to ill Steerage, otherwhiles to the variation of the Needle, or to some mistake in the Reckonings, or to some Errour in their Plots, or to some Current, or such other accident, and so the Errour hath rested unreformed. Wherefore although the practical performance of this Problem for finding the Circumference of the Earth, or the quantity of a *Degree* on the same, have many singular uses which I cannot now touch; yet that which amongst the rest I chiefly aimed at, was, that we might have a more sure and evident ground for dividing the *Log-line*, and for reckoning the Ships way or distance run more truly upon any Rumb or Point of the Compass then formerly.

And now to apply it to this purpose, we have noted before (*Chap.* 2.) that by the Experiment there expressed, we find in a *Degree* on the Circumference of the Earth and Sea, 367200 of our *English* Feet. Wherefore retaining still the same division of a *Degr.* into 60 Miles or 20 Leagues (as hath been formerly used) a Mile will contain 6120 Feet, or 1020 Fathoms: and so a League contains 18360 Feet, or 3060 Fathoms; for dividing 367200 by 60, the Quotient is 6120, *&c.* Thus then 60 Miles being a *Degree*, every Mile is 6120 Feet.

Now supposing the time of the running out of the *Log-line* to be measured by a half Minute-glass, if we observe how many Feet or Fathom she runs in half a Minute, we may thereby find her way for an hour or 4 hours, or for any other time proposed.

As admit there runs out of the *Log-line* in half a minutes ſpace 51 Feet, or $8\frac{1}{2}$ Fathoms, and you would know what way the Ship makes every hour after the ſame rate;

Say by the Rule of Proportion;

If $0\frac{1}{2}$ Minutes, give 51 Feet,
What gives 60 Minutes; Or,
If 1 Minute gives 102 Feet:
What gives 60 Minutes?

And ſo Multiplying; you ſhall find 6120 Feet, which is one Mile. Or, if you would find her way for 4 hours, which is 240 Minutes; ſay,

As 1 minute, is in proportion to 240 minutes,
So are 102 Feet, to 24480 Feet or 4 miles.

Or, if you would have it in Fathoms; ſay,

As 1 minute is in proportion to 240 minutes;
So is 17 Fathoms, to 4080 Fathoms, the Ships way in four hours. The like is to be conceived, if your Glaſs be for any other quantity of time above or under half a minute.

Some have thought that the way which the Ship maketh, may be known to an old Sea-man by experience (as they ſay) that is by conjecture: Which Opinion makes ſome neglect the uſe of the *Log*, leſt they ſhould be accounted young Sea-men. But as he that rides often will have ſome near gueſs how far the pace he rides will carry him in an hour (becauſe he hath often obſerved it formerly) ſo he which hath often ſailed and kept an account of the Ships way by the *Log*, will be able to give ſome near eſtimate of her way without the *Log*. But it is incident to ſome men to have ſuch a conceit of this their eſtimate, that they think it more certain than the Rule it ſelf, from whence it is derived, eſpecially if it chance to anſwer their expectations at ſome times.

It is thought alſo that the Ships way may be known by two Marks on the Ships ſide, but this is doubtleſs very uncertain, both by reaſon of the ſhortneſs of the time, and in reſpect of the dead water (as they call it) by the Ships ſide. For the water which is near the Ship, is drawn along with the Ship in her

her motion, and ſo much the more, by how much it is nearer.

But if any deſire to make tryal of this way, it is to be conſidered, that 17 Foot is $\frac{1}{360}$ part of a mile, and 10 *ſec.* of a minute is $\frac{1}{360}$ part of an hour: Therefore if there be two Marks on the Ships ſide diſtant 17 Feet, if the Ship run the diſtance of theſe two Marks in 10 *ſec.* ſhe runs a mile an hour, if in 5 *ſec.* two miles an hour, if ſhe runs that diſtance in 2 *ſec.* ſhe runs 5 miles an hour. And ſo always dividing 10 *ſec.* by the number of *ſec.* in which the Ship runs in that diſtance, the Quotient ſhews the miles and parts of a mile run in an hour.

But if the diſtance of thoſe two Marks be 34 Feet, if ſhe run it in 20 *ſec.* it is after a mile an hour: if in 10 *ſec.* two miles an hour, if in 5 *ſec.* four miles an hour: and ſo always dividing 20 *ſec.* by the number of *ſeconds*, in which the Ship runs that diſtance, the Quotient ſhews how many miles the Ship runs in an hour. As if the Ship run that diſtance of 34 Feet in 8 *ſec.* then dividing 20 by 8, the Quotient is $2\frac{1}{2}$, ſhewing that ſhe runs $2\frac{1}{2}$ miles in an hour. Or, if you can conveniently make the diſtance of the two Marks on the Ships ſide to be 51 Feet (for the further they are diſtant, the better) then if the Ship run that diſtance in 30 *ſec.* it is a mile an hour, if in 10 *ſec.* it is 3 miles an hour, and ſo always dividing 30 *ſec.* by the number of *ſeconds*, in which the Ship is running that diſtance, the Quotient ſhews after that rate how many miles the Ship runs in an hour.

Otherwiſe you may do thus, Divide 17 Feet into 10 parts, and ſet as many of thoſe parts on the Ships ſide, as conveniently you may, which according to the Ships length will be more or fewer. Then when the Ship runs one of thoſe parts in a *ſec.* of time, it is a mile an hour: when two, it is two miles an hour; when 5, it is 5 miles an hour. And in general, if you divide the number of parts run by the time of running accounted in *ſec.* the Quotient ſhews what number of miles after that rate are run in an hour.

As if ſhe run 30 of thoſe parts in 5 *ſeconds*, it is 6 miles an hour; for dividing 30 by 5, the Quotient is 6; ſo if ſhe run 42 of thoſe parts in 10 *ſeconds*, dividing 42 by 10, the Quo-

tient is $4\frac{2}{10}$, which ſheweth the Ships way at that time to be after the rate of four Miles and two tenths of a Mile in an hour.

But for keeping this account of time, it may be done either by a Sand-glaſs for that purpoſe, or by pronouncing certain words or numbers: as the time wherein a man tells twice 60, pronouncing every number as faſt as he can conveniently and diſtinctly, is about a Minute; ſo that the time wherein a Man is numbring 60, is half a Minute or 30 *ſeconds*; and whilſt a Man is numbring two (as one and tweuty, two and twenty) is a *ſecond*, and ſo whilſt a Man is numbring from twenty to thirty, is five *ſeconds*, from twenty to forty, ten *ſeconds*, *&c.* but in numbring from one and twenty, you may obſerve the ſame times as in numbring from one and twenty to forty, and this will not be hard to do; for whilſt a man pronounceth one and twenty, two and twenty, three and twenty, *&c.* there remains a certain Impreſſion in the Fantaſie, whereby a man is able in the ſame times to pronounce one, two, three, *&c.* And although this rule of numbring twice 60 for a Minutes ſpace be not general unto all men, becauſe ſome are ſwifter or ſlower in their pronunciation than others; yet after this Example, a man making tryal, may frame a rule to himſelf, whereby he may come ſomething near the truth.

But leaving theſe, we come to the diviſion of the *Log-line*, according to the half Minute-glaſs, which is more uſual and certain. And conſidering that half a Minute is of an hour the $\frac{1}{120}$ part, therefore the Ships way running 51 Feet in half a Minute, is a Mile an hour; if ſhe run twice ſo much, that is, 102 Feet in half a Minute: it is two Mile an hour; if thrice ſo much, it is three Mile an hour; and in general, how many times 51 Feet ſhe runs in half a Minute, ſo many Miles in her way for an hour. Therefore leaving half a ſcore Fathoms, or more from the *Log*, that ſo it may be out of the *Eddy* of the Ships wake, before you begin to account or turn the Glaſs; if there you make a Mark for the beginning, and ſo 51 Feet from thence a Mark of one Knot, and 51 Feet further a Mark of two Knots, and 51 Feet further (that is, 153 Feet from your firſt Mark) another

Mark

Mark of three Knots, and ſo proceeding: look how many Knots are veered out in half a Minute, ſo many Miles is the Ships way for an hour. Now for that which is veered out more above the juſt meaſure of a Knot or Knots, you may allow for every five Feet the tenth part of a Mile almoſt. As admit the run 5 Knots, and 25 Feet in half a Minute, then is her way according to $5\frac{5}{10}$, or five Miles and an half in an hour, if 6 Knots and ten Feet, it is $6\frac{2}{10}$ miles in an hour, *&c.*

But according to the common Opinion of 5000 Feet to a mile, and 60 ſuch miles to a *Degree*, there ſhould be ſomething leſs than 7 Fathom, namely, $41\frac{2}{3}$ Feet to a Knot.

And although he which veers the *Log-line* be careful to overhale it ſo ſlack, that it may not draw forwards the *Log*, yet (no doubt) it doth loſe ſome way, following the Ship a little as it is drawn by the Line, and withal by the *Eddy* of the Ships wake, and ſometimes alſo is caſt forwards by the Wind and Waves, when they come after the Ship; ſo that for theſe cauſes, it is like, there may ſometimes be allowed three or four Fathoms more than is veered out; but this (as a thing mutable and certain) being ſometimes more, ſometimes leſs, cannot be brought to any certain Rule, but ſuch allowance may be made for it as a man in his experience and diſcretion finds fit.

If you would divide the *Log-line* ſo as it might give the Ships way in *Centeſms*, or the hundredth part of a *Degree*, and fit it to half a Minute-glaſs. Then ſeeing the hundredth part of a *degree* is 3672 Feet, and the $\frac{1}{120}$ part thereof is $30\frac{3}{5}$ Feet; If you begin at the mark at which you mean to turn the Glaſs, and meaſure from thence 30 Feet, and 3 fifth parts of a Foot, you may there place 1 Knot; and thence again meaſuring 30 Feet, and 3 fifth parts of a Foot, there place 2 Knots; and ſo proceeding at the end of every 30 Feet and 3 fifths, adding a Knot, the number of Knots which run out in half a Minute, is the number of *Centeſms* which the Ship runs in an hour. As ſuppoſe there run out ten Knots in half a Minute, then the Ships way according to ten *Centeſms* to a *degree* in an hour, that is, the tenth part of a *Degree*, or ſix Miles. And ſo every three Foot above the

juſt

juſt meaſure of Knots, is near the tenth part of a *Centeſm*, or the 1000*th* part of a Degree. As if there run out of the *Log-line* 5 Knots and 12 Feet, then the Ships way for an hour is 5 *Centeſms*, and four tenth part of a *Centeſm*: the like is to be underſtood of others.

And after the form of theſe Examples you may divide the *Log line* for any othet quantity of Time, more or leſs than half a minute, or for any other parts of a Degree propoſed.

Thus have we handled the Diviſion of the *Log-line*, according to the meaſure before found of 367200 *Engliſh*-Feet in a Degree: But becauſe (as I have before ſhewed) the Ships way is commonly more than by the *Log line* it appears to be, and every man deſires to have his reckoning ſomething before his Ship, that he fall not with a place unexpected; for theſe, and ſuch other cauſes; and for the rotundity of the number, if any man think it more ſafe and convenient in Sea-reckonings, he may abate one in 51, and ſo aſſign to a Degree only 360000 Feet, and conſequently to a mile 6000 *Engliſh*-Feet.

And upon this ground, if in half a minute there run out 50 Feet of the *Log-line*, it is a mile an hour; and ſo if 100 Feet run out in a minute.

For, as 1 minute is in proportion to 60 minutes:
So is 100 Feet to 6000 Feet.

And ſo foraſmuch as twenty five Feet is $\frac{1}{240}$ part of a mile, and 15 *ſeconds* is alſo $\frac{1}{240}$ part of an hour: Therefore if there be two Marks on the Ships ſide diſtant 25 Feet, if the Ship run the diſtance of theſe two Marks in 15 *ſeconds*, it is after the rate of a mile an hour; if in 5 *ſeconds*, it is 3 miles an hour; and ſo always dividing 15 *ſeconds* by the number of *ſeconds* in which the Ship runs that diſtance; the Quotient ſhews the miles and parts of a mile run in an hour. But if the diſtance of theſe two Marks be 50 Foot, then if ſhe run it in 30 *ſeconds*, or half a Minute, it is a mile an hour; if in 10 *ſeconds*, 3 miles an hour; if in five *ſeconds*, ſix miles an hour, (for 30 divided by five, the Quotient is 6.) And ſo always dividing thirty *ſeconds* by the number of *ſeconds*, in which the Ship runs that Diſtance;

ſtance; the Quotient ſhews how many miles ſhe runs in an hour, *&c*,

Otherwiſe, if you make a mark on the Ships ſide at every twenty Inches, then when the Ship runs one of theſe parts in a *ſecond* of time, it is a mile an hour: when five: it is five miles an hour, if ſhe run 18 of theſe parts in three *ſeconds*, it is ſix mile an hour. For dividing 18 by 3, the Quotient is ſix, And in general, if you divide the number of the parts run, by the number of *ſeconds* ſpent in running, the Quotient ſhews the Ships way in miles for an hour.

But for dividing the *Log-line* according to this ground of 6000 Feet in a Mile, if you intend to uſe it with a half Minute-glaſs; then becauſe half a Minute is $\frac{1}{120}$ part of an hour, and 50 Feet is alſo the $\frac{1}{120}$ part of a Mile: Therefore when the Ship runs 50 Feet in half a Minute, her way is after the rate of a Mile an hour; if 100 Feet in half a Minute, it is two Miles an hour, *&c*.

Therefore half a ſcore Fathoms or more from the *Log*, you may make a Mark, and beginning from thence meaſure 50 Feet, and there make the firſt Knot, and 50 Foot farther two Knots, and 50 Foot farther three Knots, and ſo proceeding: Look how many Knots is run out in half a Minute, ſo many Miles is the Ships way for an hour: and every 5 Feet more beſides the knots, is a tenth part of a Mile; as if there run out 6 Knots and 20 Feet in half a Minute, the Ships way is after the rate of $6\frac{4}{10}$ Miles in an hour, *&c*.

And ſo if the Glaſs were for any other time more or leſs than half a Minute, you may make the diſtance of your Knots proportional: as if it were for 20 *ſeconds*, then becauſe 20 *ſeconds* is of an hour the $\frac{1}{180}$ part, I divide a Mile, which is 6000 Feet, by 180, and the Quotient is $33\frac{1}{3}$; therefore there muſt be a Knot at every 33 Feet and 4 Inches.

If your Glaſs be 36 *ſeconds*, which is $\frac{1}{100}$ part of an hour, divide 6000 by 100, the Quotient is 60, ſhewing that there muſt be 60 Feet to every Knot, and then every 6 Foot over and above the Knots, is a tenth part of a Mile more.

And

And ſo it is better that your Glaſs be more than half a Minute rather than leſs; and the more the better, provided that there run out no more Line then you may hale in again, without danger of breaking.

Laſtly, if you would ſo divide the *Log-line*, that it might ſhew the Ships way in *Centeſms* of a *Degree*, and fit it to an half Minute-glaſs. Then forаſmuch as the hundreth part of a *degree* is 360 Feet, and the $\frac{1}{120}$ part thereof is 30 Feet; therefore beginning at the mark whereat you intend to turn the Glaſs, meaſure from thence 30 Feet, and there make one Knot, and at 30 Feet farther two Knots, *&c.* Then look how many Knots run out in half a Minute, ſo many *Centeſms* of a *Degree* is the Ships way for an hour. And ſo if the Glaſs be 36 *ſeconds*, then every Knot muſt have 36 Feet, *&c.*

Now if a man Sailing between any two places which lie near Eaſt and Weſt one from another, have kept his Reckoning by Courſe and Diſtance, uſing a *Log line* ſo divided, that it have a Knot at every 7 Fathoms (as many do) and would reduce the Diſtance of thoſe two places ſo found, to their Diſtance in ſuch Miles, as theſe of 60 to a *Degree*, each containing (as we have ſaid) 6000 Feet: The proportion in number of thoſe to theſe, is as 6 to 5, for 6 of them make 5 of theſe.

As admit a man in his dead Reckoning, uſing ſuch a *Log-line* as hath a Knot at every 7 Fathoms, and for every Knot running out in half a Minute, he accounts the Ships way to be ſo many miles an hour; and according to ſuch a Reckoning, ſuppoſe he find the diſtance of two places to be 1224 miles, or 408 Leagues, and would know the Diſtance of the ſame places in miles of 6000 Feet to a Mile, which is according to a *Log-line* that hath a Knot at every 50 Feet.

Say then by the Rule of Proportion;		
As the number 6	*Co. ar.*	9.22185
Is in proportion to 5		0.69897
So is the number of miles given 1224		3.08778
To the number of miles required, 1020		3.00860.

Which

Which 1020 is the diſtance of thoſe two places, in ſuch miles whereof 60 make a *degr.* Or to find the ſame in Leagues, the Proportion is, As 6 to 5, ſo is 408 Leagues, to 340 Leagues.

And thus may the Diſtances of Places be found in ſuch miles, whereof 60 make a *degr.* eſpecially if with the diſtance expreſſed in the *Plain Chart*, you compare the reckonings of ſome skilful Mariners that have ſailed from the one to the other. But thus to endeavour a reformation of the *Plain Chart*, were a Labour to little purpoſe; For there the correcting of the true ſituation of two places, in reſpect of one another, is oftentimes an occaſion that the ſame places are the more falſly ſituate in reſpect of others. Like as if there were two places 8 miles diſtant, and it were required to place a third three miles from either of them; Here, if we ſet the third in the middle, it will be four miles diſtant from either: But if (attempting to mend that Errour) we make the third to be three miles from the firſt, then will it be 5 miles from the ſecond: And thus unavoidably, the mending of the one is the marring of the other; becauſe the thing propoſed is not poſſible.

And ſuch is the Errour of the plain or common *Sea-Chart*, repreſenting the Earth and Sea, not as a Spherical, but as a Plain *Superficies*; not as if the Meridians did concur in the Poles, but as if they were always parallel one to another. So that the graduation and projection being ſuch, the Situations and Diſtances of places cannot be generally and truly expreſſed therein.

But the graduation and projection of *Mercator*'s *Chart*, agreeing without ſenſible errour with the *Globe*, there may in that be deſcribed all or any parts of the World, according to their Longitudes, Latitudes, Courſes and Diſtances, as truly, and far more conveniently for the *Mariners* uſe than upon the *Globe* it ſelf; and upon ſuch a *Chart* ſo deſcribed, a reckoning may be truly kept, and any Errour committed may eaſily be diſcerned and amended. Whereas on the *Plain Chart*, if a man find his reckoning to diſagree, he is ſo far from knowing how to amend it, that he can ſeldom conjecture where the fault was.

The neglect and want of these *Charts*, hath been, and is a great imperfection in *Navigation* and *Geography*. For howsoever there be some which do daily set forth for sale Maps of the World, and of the parts thereof, according to this projection: Yet to have them truly such, and fit for *Navigation*, requires in the Author or Maker of them good knowledge, and some competent ability of his own, or aid from others, with a greater love to the Truth, than to his own Profit, which may induce him to bestow such Industry, Time and Expence, as I have formerly noted to be requisite in such a Work.

For the furtherance whereof, and of the Practice of *Navigation* in general, I shall endeavour in the two next Chapters to shew a methodical and orderly way of keeping a reckoning at Sea, more distinctly and exactly than hath been formerly used, and such as may aptly be set down in any *Chart*, and applied in the three principal kinds of Sailing; namely, according to the *Plain Chart*, or *Mercator's*, or according to the Arch of a great *Circle*. And by a few reckonings truly set down, according to this form, the Maps of the World, and of the parts thereof, might be much reformed.

CHAP. VIII.

A formal and exact way of setting down and perfecting a Sea-reckoning.

ALthough the Course and Distance cannot be so truly and certainly known as the Latitude may be; yet we must endeavour in these also to come as near the Truth as may be, the rather for that some reckonings must necessarily depend wholly upon them. And to that end, those which in their Voyages at Sea, have occasion to run far upon any Course or Courses near the Meridian, may do well to make trial of that which I have formerly set down, touching the quantity

tity of a *degr.* on the Earth and Sea in our known Meaſure; and eſpecially in *Eaſt-Indian* Voyages; Sailing from the *Lizard* in the Weſt part of *England*, to *Cape bon Eſperance* in *Africk*, they have opportunity of making an ample Experiment hereof.

But leaving this to the Practice of the skilful and induſtrious *Sea man*, we come now to ſhew an orderly and exact way of framing and keeping a reckoning at Sea; for which purpoſe I have made the *Table* following, which ſheweth how much a Ship is more Northerly or Southerly, and how much more Eaſterly or Weſterly, by Sailing upon any Point or half Point of the *Compaſs*, any number of Miles propoſed.

The like *Table* I made many years ſince, and taught the Uſe of it in *Navigation*; whether it were then uſed by any other, I know not, I had it of no man; but this I ſpeak, that if any man claim the firſt making and uſe of ſuch an one, he may have it.

The Ground of making this *Table* is the ſame with the former. *For as* Radius *is in proportion to the Diſtance run, So is the Sine Complement of the* Rumb, *to the Diſtance of North or South, and ſo is the Sine of the* Rumb, *to the Diſtance of Eaſt or Weſt.* Therefore here for 10 miles upon any of the four Points from the Meridian, we ſet in the ſecond Column the Sine Complement of that Point (reduced into *degr.*) and in the third the Sine thereof. As the ſecond Rumb or Point from the Meridian, being 22 *degr.* 30 *min.* the Sine Complement thereof which is 9239 ſet in the ſecond Column againſt 10: and the Sine thereof 3827, I ſet there in the third Column, and having done thus for 10 miles in every Column, the reſt may be eaſily drawn from them.

As in the ſecond Column, for the firſt half Point againſt 10 miles, finding 9952, I ſet the half thereof; namely, 4976 againſt 5 miles, and the tenth part thereof, namely, 995 againſt one mile, which doubled or added to it ſelf, is 1990, to be ſet againſt two miles, whereto adding the ſame 995, the Sum is 2985 for three miles; and ſo for the reſt.

And thus for every Point and half Point from the Meridian, there are three Columns: In the firſt whereof, there is ſet down a number of Miles run upon that Point or half Point; the *ſecond* ſheweth how much the Latitude is altered; that is, how much you are more Southerly or Northerly, by running ſo far upon that Point or half Point; the *third*, how much you are more Eaſterly or Weſterly; by running that Courſe and Diſtance.

The numbers ſet in every firſt Column from 1 to 10, are alſo to be underſtood from 10 to 100, or from 100 to 1000, and the Figure in the fourth place of the ſecond and third Columns, anſwer to the firſt. As admit a Ship run South and by Weſt (that is (South 1 Point Weſterly) 165 Miles) I ſet down this number thus; and looking in the Columns of the firſt *Rumb* againſt 10 (which may be underſtood to be 100 (I find againſt it in the ſecond Column 981 almoſt, and in the third 195, alſo againſt 60 (that is 6) in the firſt Column, there is 588 in the ſecond, and 117 in the third: alſo againſt 5 in the firſt Column, there is 49 in the ſecond, and almoſt 10 in the third.

	100	981	195
S.W. 1.	60	588	117
point.	5	49	10
	165.	161.8	32.2

Theſe ſet down, and ſumm'd up as here appeareth, ſhew that a Ship running *S* by *W* 165 Miles, is to the Southwards of the place from whence ſhe departed 161 Miles, and 8 Tenth parts of a mile, and to the Weſtwards 32 miles, and 2 Tenth-parts of a mile. If you deſire more exactneſs, you may uſe all the places for the firſt or greateſt number, which is here 100.

	100	9809	1950
S.W. 1.	65	5885	1170
point.	5	490	97
	165	161.83	32.17

As in this ſecond Example, where the Southerly Diſtance is 161 $\frac{83}{100}$ miles, and the Weſterly 32 $\frac{17}{100}$ miles.

A Table

A Table of the Northing or Southing, Easting or Westing of every Rumb and half Rumb from the Meridian, according to the number of Miles run upon that Rumb.

	½ point.	7½ poin	1 point.	7 point.	1½ poin	6½ poin.	2 point.	6 point.
M	5.37 ½	84.22½	11. 15	78. 45	16. 52	73. 7½	22. 30	67. 30
1	·995	·098	·981	·195	·957	·290	·924	·383
2	1.990	196	1.962	.390	1914	·580	1.848	·766
3	2.986	294	2943	.585	2871	·870	2.772	1.148
4	3.981	392	3.923	.780	3827	1.161	3.696	1.531
5	4.976	490	4.904	·975	4784	1.451	4.620	1.914
6	5.971	588	5.885	1.170	5741	1.741	5.544	2.297
7	6.966	.686	6.866	1.365	6698	2.031	6.458	2.680
8	7.961	·784	7.846	1.560	7.655	2.321	7.392	3.062
9	8.957	·882	8.827	1.755	8612	2.612	8.315	3.445
10	9.952	·980	9.808	1.950	9.569	2.902	9.239	3.827

	2½ poin.	5½ poin.	3 point.	5 point.	3½ poin.	4½ poin.	4 point.	4 point.
M	18. 7½	61.52⅓	33. 45	56. 15	39.22½	50.37½	45. 00	45. 00
1	·882	.471	·831	·556	·773	·634	·707	·707
2	1.764	·942	1.663	1.111	1.546	1.269	1.414	1.414
3	2.646	1.414	2.494	1.667	2.319	1.903	2.121	2.121
4	3.528	1.885	3.326	2.222	3.092	2.538	2.828	2.828
5	4.410	2.357	4.158	2.778	3.865	3.172	3.535	3.535
6	5.292	2.828	4.989	3.334	4.638	3.806	4.242	4.242
7	6.174	3.300	5.820	3.890	5.411	4.440	4.949	4.949
8	7.056	3.771	6.652	4.445	6.184	5.075	5.656	5.656
9	7.937	4.243	7.483	5.000	6.957	5.710	6.364	6.364
10	8.819	4.714	8.315	5.556	7.730	6.344	7.071	7.071

A larger Example may be that before set down in the last *Problem* of Sailing by a *Great Circle* from *Summers Islands* to the *Lizard*, pag. 127. As

As admit I ſail from thence; Firſt, *N E* ½ Point Eaſterly 600 miles, then *N E* by *E* 300 miles; Eaſt North-Eaſt half a Point Northerly 495 miles; *E N E* 390 miles; *E N E* ½ Point Eaſterly 264 miles; *E* by *N* 210 miles; Eaſt 951 miles: Theſe Courſes and Diſtances I ſet down in ſuch form as here appeareth, where in the firſt Column there is expreſſed the Courſe or Point of the Compaſs upon which a man ſails: In the ſecond Column, the Diſtance of that Rumb from the Meridian. In the third Column, the Diſtance run upon that Point; In the reſt, the difference of Latitude, and departure from the Meridian in Miles, and tenth parts of a Mile.

Courſe.	*Rumb from me.*	*Diſt. miles.*	*North.*	*South*	*Eaſt.*	*Weſt.*
N E ½ Po. *E.*	*North Eaſterly.* 4 ½ P.	600	380.6		4638	
N E by *E.*	*N Eaſt* 5 Point.	300	166.7		2494	
E N E ½ Po *N.*	*N Eaſt* 5 ½ Po	400	1885		3528	
		90	424		794	
		5	24		44	
E N E	*N Eaſt*	300	1148		277.2	
	6 Point.	90	344		831	
E N E ½ Po. *E.*	*N Eaſt* 6 ½ Point.	200	580		1914	
		60	174		574	
		4	12		38	
E by *N*	*N Eaſt* 7 Point.	200	390		1962	
		10	20		98	
		900			9510	
Eaſt.	*Eaſt.*	50				
		1				
		3210	1047.4		22197	

(In all which is to be conceived, that the *Variations* are allowed) ſo that at the Foot of this reckoning, I find the Sum of the North Column to be 1047 $\frac{4}{10}$ miles, and the Sum of the Eaſt Column 2910 miles almoſt; the firſt, namely, 1047 miles converted into *degr.* is 17 *degr.* 27 *min.* the difference of Latitude, which added to the Latitude of *Summers Iſlands* 32 *deg.* 25 *min.* (where this reckoning began) the Sum is 49 *degr.* 52 *min.* which is the Latitude of this laſt place where this reckoning endeth. So that according to this Account, the Ship is run into the Latitude of 49 *deg.* 52 *min.* and hath altered her Longitude to the Eaſtwards 2920 miles, of ſuch miles, whereof 60 make a *degr.* of a great Circle.

Therefore if you ſet down this reckoning on the *Plain Chart*, you muſt make a Point in the *Chart* that may be in the Latitude of 49 *deg.* 52 *min.* and to the Eaſtwards of *Summers Iſlands*. (where this reckoning began) 2920 miles, that is, you muſt run a parallel (with your Compaſſes or otherwiſe) on your *Chart* in the Latit. of 49 *degr.* 52 *min.* and croſs the ſame by a Meridian, which may be to the Eaſtwards of the Merid. of *Summers-Iſlands* 2920 miles, and ſo the Point of the Interſection of this Parallel and Meridian, is the traverſe-Point or Point in the *Chart* repreſenting the place where the Ship is in the end of this reckoning.

But if you ſet down this reckoning on *Mercator's Chart*, you muſt alſo find a Point that may be in the Latitude of 49 *degr.* 52 *min.* and may likewiſe be to the Eaſtwards of *Summers-Iſlands* 2920 miles, which is done by running with your Compaſſes a Parallel in the Latitude of 49 *degr.* 52 *min.* and croſſing the ſame by a Meridian, which may be to the Eaſtwards of the Meridian of *Summers-Iſlands*, 2920 miles, the Point of the Interſection of this Parallel with that Meridian, is the Traverſe-point, repreſenting in the *Chart* the place where the Ship then is.

For it is to be conceived in this *Chart*, that the *Degrees* of the Meridian intercepted between the Latitudes of two places, are as a Scale for thoſe two places, to meaſure not only their difference of Latitude, but likewiſe their Diſtance in their Rumb, as alſo the Diſtance of their Meridians.

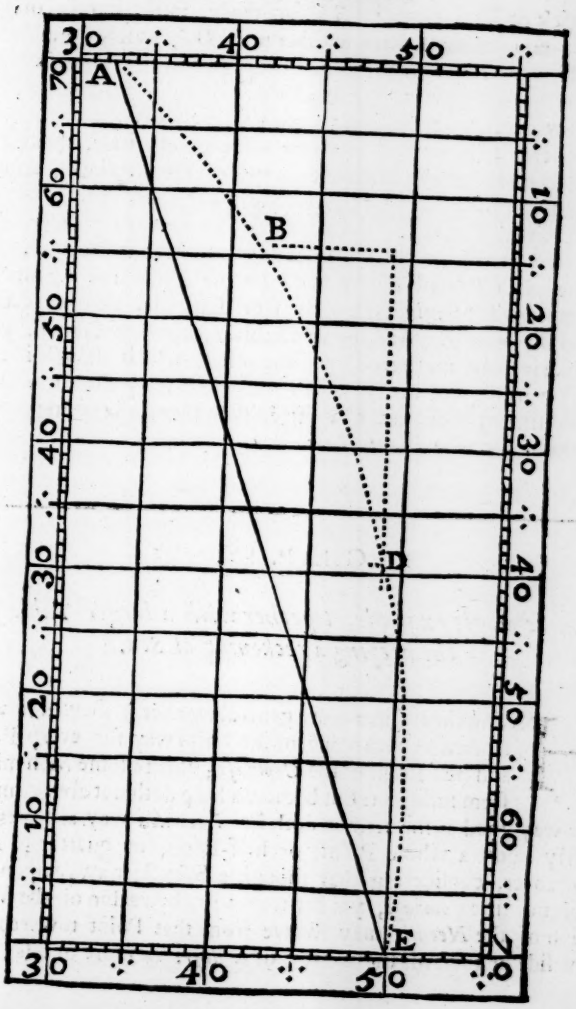
But

But becauſe it often falls out, that in Sailing from place to place, a Ship runs not near the Rumb of the two places by many hundred miles, eſpecially in ſailing by the Arch of a *great Circle*, which is the moſt exquiſite manner of Sailing, and wherein a man ſhifts his Courſe often, and runs much farther in one Latitude than in another, as by the former Example may appear. Therefore once in three or four days, or ſo often as you alter your Courſe much, you may tranſfer or ſet down your Reckoning out of your Book into your *Chart*. As in tranſferring the former Example, you may ſet down the Northing and Eaſting of every of the Courſes ſeverally; but for brevity ſake we will bring them into three parts (and ſo alſo we ſhall not much err.

And thus for the two firſt Courſes, namely *N E* ½ Point Eaſterly 600 miles, and *N E* by *E* 300 miles, I find in the North Column 547 Miles; and in the Eaſt Column 713 miles; alſo for the three next Courſes, ſumming up the North and Eaſt Columns, I find the Northing to be 459 miles; and the Eaſting 1050 miles. Alſo for the two laſt Courſes, I find the Northing to be 41 miles, and the Eaſting 1157 miles.

North.	*Eaſt.*
547	713
459	1050
41	1157
1047	2920

Now to tranſfer theſe into the *Chart*, I conſider that 547 miles is 9 *degr.* 7 *min.* which added to the former Latitude 32 *deg.* 25 *min.* makes Latitude 41 *degr.* 32 *min.* In which Latitude I run a Parallel, then conſidering that 713 miles is 11 *degr.* 53 *min.* I take this 11 *degr.* 53 *min.* in the Meridian, as much above the one Latitude, as beneath the other, namely, from 31 *degr.* 0 *min.* to 42 *degr.* 53 *min.* and this I ſet in the foreſaid Parallel from the Meridian of *Summers Iſlands* to the Eaſtwards, and there make the Point *B*, then reducing 459 miles into *degr.* it makes 7 *deg.* 39 *min.* which added to 41 *deg.* 32 *min.* makes Latitude 49 *deg.* 11 *min.* Alſo the Eaſting 1050 miles are 17 *deg.* 30 *min.* the half whereof 8 *deg.* 45 *min.* I take in the Meridian from above 41 *deg.* 32 *min.* beneath 49 *deg.* 11 *min.* namely, from 41 *deg* 20 *min.* to 50 *deg.* 5 *min.* And this being doubled (becauſe it is but the half) I ſet from the Meridian of the


A
B
D
E
30
40
50
70
60
50
40
30
20
10
10
20
30
40
50
60
70

the Prick or Traverſe-point *B* before made, in the Parallel of 49 *deg.* 11 *min.* making there another prick *D*. Laſtly, I add the Northing 41 miles to the former Latitude 49 *deg.* 11 *min.* the Sum is 49 *deg.* 52 *min.* the Latitude of the Parallel to which I am now come, wherein I am to ſet down the Eaſting 1157 miles. This therefore converted into *degr.* of a great Circle, make 19 *degr.* 17 *min.* I take therefore 1 *degr.* of the Meridian, about the Latitude of 49 *degr.* 52 *min.* (becauſe the moſt part is run in that Latitude) namely, from 49 *degr.* 30 *min.* to 50 *degr.* 30 *min.* and ſet the ſame in the foreſaid Parallel from the Meridian of the prick *D* laſt before made to the Eaſtwards 19 times, and moreover 17 *min.* take at the ſame Latitude, and this reacheth to the point *E*. And ſo is all this reckoning ſet down, and the like is to be underſtood of any other, which though in expreſſion it require many words for plainneſs, yet is there very little difficulty more in the Practice, than there is in ſetting down a reckoning on the *Plain Chart*.

CHAP. IX.

A more ample example, together with a larger Table for the keeping a reckoning at Sea.

HAving thus (in a more general manner) ſhewed how to ſet down a reckoning of the Ships way for every Point and half Point of the *Compaſs*; this to ſome Men might ſeem ſufficient: But becauſe a Ship doth not always make her way good as ſhe lies, nor doth her *Leeward*-way alwayes fall juſtly upon a whole Point, or half-Point, or quarter; And moreover, conſidering that though a Ship ſteer away upon any Point of the *Compaſs*, yet her true way, by reaſon of the Variation of the *Needle*, may ſwerve from that Point towards the one ſide or towards the other 3 or 4 *degr.* or more or leſs, and not

B
C

not alwayes a Point or half-Point, or quarter; therefore I have thought it requiſite to ſet down the Table following to every ſingle *degr.* and that a man might the more readily with one or two Entrances have his deſire, I have alſo enlarged the number of miles unto 100. The Ground and way of making this Table, differs not from the former, and it is to be uſed almoſt in the ſelf ſame manner: wherefore we ſhall uſe the more brevity in handling it.

Here followeth a Table of the Northing or Southing, Eaſting or Weſting of every *degr.* from the Meridian, according to the number of Miles run upon that *degr.* *which for brevity ſake we call* ——

A

TABLE

FOR THE

DIFFERENCE

OF

LATITUDE,

AND

Departure from the *Meridian.*

M.	1 d.	89d	M.	1 d.	89d	Min.	1 d.	89 d.
1	10	.0	35	350	6	69	690	12
2	20	0	36	360	7	70	700	12
3	30	0	37	370	7	71	710	13
4	40	1	38	380	7	72	720	13
5	50	1	39	390	7	73	730	13
6	60	.1	40	400	7	74	740	13
7	70	.1	41	410	7	75	750	13
8	80	1	42	420	7	76	760	13
9	90	2	43	430	8	77	770	14
10	100	.2	44	440	8	78	780	14
11	110	.2	45	450	8	79	790	14
12	120	.2	46	460	8	80	800	14
13	130	2	47	470	8	81	810	14
14	140	.2	48	480	9	82	820	14
15	150	.3	49	490	9	83	830	15
16	160	.3	50	500	9	84	840	15
17	170	.3	51	510	6	85	850	15
18	180	.3	52	520	9	86	860	15
19	190	3	53	530	9	87	870	15
20	200	.4	54	540	10	88	880	15
21	210	4	55	550	10	89	890	16
22	220	4	56	560	10	90	900	16
23	230	.4	57	570	10	91	910	16
24	240	4	58	580	10	92	920	16
25	250	4	59	590	10	93	930	16
26	260	5	60	600	11	94	940	17
27	270	5	61	610	11	95	950	17
28	280	5	62	620	11	96	960	17
29	290	5	63	630	11	97	970	17
30	300	5	64	640	11	98	980	17
31	310	5	65	650	12	99	990	17
32	320	.6	66	660	12	100	1000	18
33	330	6	67	670	12	200	2000	35
34	340	.6	68	680	12	300	3000	53

M.	2 d.	88d
1	10	0
2	20	1
3	30	1
4	40	1
5	50	2
6	60	2
7	70	2
8	80	3
9	90	3
10	100	3
11	110	4
12	120	4
13	130	4
14	140	5
15	150	5
16	160	6
17	170	6
18	180	6
19	190	7
20	200	7
21	210	7
22	220	8
23	230	8
24	240	8
25	250	9
26	260	9
27	270	9
28	280	10
29	290	10
30	300	10
31	310	11
32	320	11
33	333	11
34	340	12
35	350	12
36	360	13
37	370	13
38	380	13
39	390	14
40	400	14
41	410	14
42	420	15
43	430	15
44	440	15
45	450	16
46	460	16
47	470	16
48	480	17
49	490	17
50	500	17
51	510	18
52	520	18
53	530	18
54	540	19
55	550	19
56	560	19
57	570	20
58	580	20
59	590	20
60	600	21
61	610	21
62	620	22
63	630	22
64	640	22
65	650	23
66	660	23
67	670	23
68	680	24

Min.	2 d.	88 d.
69	690	24
70	700	24
71	710	25
72	720	25
73	730	25
74	740	26
75	750	26
76	760	26
77	770	27
78	780	27
79	790	28
80	800	28
81	809	28
82	819	29
83	829	29
84	839	29
85	849	30
86	859	30
87	869	30
88	879	31
89	889	31
90	899	31
91	909	32
92	919	32
93	929	32
94	939	33
95	949	33
96	959	34
97	969	34
98	979	34
99	989	35
100	999	35
200	1999	70
300	2998	105

M	3 d.	87 d
1	10	1
2	20	1
3	30	1
4	40	2
5	50	2
6	60	3
7	70	4
8	80	4
9	90	5
10	100	5
11	110	6
12	120	6
13	130	7
14	140	7
15	150	8
16	160	8
17	170	9
18	180	9
19	190	10
20	200	10
21	210	11
22	320	11
23	230	12
23	240	12
25	250	13
26	260	13
27	270	14
28	280	15
29	290	15
30	300	16
31	310	16
32	320	17
33	330	17
34	340	18

M.	3 d.	37 d
35	350	18
36	360	19
37	370	19
38	380	20
39	390	20
40	400	21
41	410	21
42	420	22
43	430	22
44	440	23
45	450	23
46	460	24
47	470	24
48	480	25
49	490	26
50	500	26
51	509	27
52	519	27
53	529	28
54	539	28
55	549	29
56	559	29
57	569	30
58	579	30
59	589	31
60	599	31
61	609	32
62	619	32
63	629	33
64	639	33
65	649	34
66	659	35
67	669	35
68	679	36

Min.	3 d.	87 d.
69	689	36
70	699	37
71	709	37
72	719	38
73	729	38
74	739	39
75	749	39
76	759	40
77	769	40
78	779	41
79	789	41
80	799	42
81	809	42
82	819	43
83	829	43
84	839	44
85	849	44
86	859	45
87	869	45
88	879	46
89	889	46
90	899	47
91	909	48
92	919	48
93	929	49
94	939	49
95	949	50
96	959	50
97	969	51
98	979	51
99	989	52
100	999	52
102	1997	105
103	2996	157

M.	4 d.	86 d
1	10	1
2	20	1
3	30	2
4	40	3
5	50	3
6	60	4
7	70	5
8	80	6
9	90	6
10	100	7
11	110	8
12	120	8
13	130	9
14	140	10
15	150	10
16	160	11
17	170	12
18	180	13
19	190	13
20	200	14
21	209	15
22	219	15
23	229	16
24	239	17
25	249	17
26	259	18
27	269	19
28	279	20
29	289	20
30	299	21
31	309	22
32	319	22
33	329	23
34	339	24
35	349	25
36	359	25
37	369	26
38	379	27
39	389	27
40	399	28
41	409	29
42	419	29
43	429	30
44	439	31
45	449	31
46	459	32
47	469	33
48	479	34
49	489	34
50	499	35
51	509	36
52	519	36
53	529	37
54	539	38
55	549	38
56	559	39
57	569	40
58	579	40
59	589	41
60	599	42
61	609	43
62	619	43
63	629	44
64	639	45
65	648	45
66	658	46
67	668	47
68	678	48

Min.	4 d.	86 d.
69	688	48
70	698	49
71	708	50
72	718	50
73	728	51
74	738	52
75	748	52
76	758	53
77	768	54
78	778	55
79	788	55
80	798	56
81	808	57
82	818	57
83	828	58
84	838	59
85	848	59
86	858	60
87	868	61
88	878	61
89	888	62
90	898	63
91	908	63
92	918	64
93	928	65
94	938	66
95	948	66
96	958	67
87	968	68
98	978	68
99	988	69
100	998	70
200	1904	140
300	2995	209

M.	5 d.	85 d	M.	5 d.	85 d	Min.	5 d.	85 d.
1	10	1	35	349	30	69	687	60
2	20	2	36	359	31	70	697	61
3	30	3	37	369	32	71	707	62
4	40	3	38	379	33	72	717	63
5	50	4	39	388	34	73	727	64
6	60	5	40	398	35	74	737	65
7	70	6	41	408	36	75	747	65
8	80	7	42	418	37	76	757	66
9	90	8	43	428	37	77	767	67
10	100	9	44	438	38	78	777	68
11	110	10	45	448	39	79	787	69
12	120	10	46	458	40	80	797	70
13	130	11	47	468	41	81	807	71
14	140	12	48	478	42	82	817	71
15	150	13	49	488	43	83	827	72
16	159	14	50	898	44	84	837	73
17	169	15	51	508	45	85	847	74
18	179	16	52	518	45	86	857	75
19	189	17	53	528	46	87	867	76
20	199	17	54	538	47	88	877	77
21	209	18	55	548	48	89	887	78
12	219	19	56	558	49	90	897	78
23	229	20	57	568	50	91	907	79
24	239	21	58	578	51	92	916	80
25	249	22	59	588	52	93	926	81
26	259	23	60	598	52	94	936	82
27	269	24	61	608	53	95	946	83
28	279	24	62	618	54	96	956	84
29	289	25	63	628	55	97	966	84
30	299	26	64	638	56	98	876	85
31	309	27	65	648	57	99	886	86
32	319	28	66	658	58	100	896	87
33	329	29	67	668	58	200	1992	174
34	239	30	68	677	59	300	2989	262

M	6 d.	84d
1	10	1
2	20	2
3	30	3
4	40	4
5	50	5
6	60	6
7	70	7
8	80	8
9	89	9
10	99	10
11	109	11
12	119	12
13	129	14
14	139	15
15	149	16
16	159	17
17	169	18
18	179	19
19	189	20
20	199	21
21	209	22
22	219	23
23	229	24
24	239	25
25	249	26
26	259	27
27	268	28
28	278	29
29	288	30
30	298	21
31	308	32
32	318	33
33	328	34
34	338	35

M.	6 d.	84d
35	348	36
36	358	38
37	368	39
38	378	40
39	388	41
40	398	42
41	408	43
42	418	44
43	428	45
44	438	46
45	447	47
46	457	48
47	467	49
48	477	50
49	487	51
50	497	52
51	507	53
52	517	54
53	527	55
54	537	56
55	547	57
56	557	58
57	567	59
58	577	61
59	587	62
60	597	63
61	607	64
62	617	65
63	627	66
64	637	67
65	646	68
66	656	69
67	666	70
68	676	71

Min.	6 d.	84 d.
69	686	72
70	696	73
71	706	74
72	716	75
73	726	76
74	736	77
75	746	78
76	756	79
77	766	80
78	776	81
79	786	82
80	796	83
81	806	85
82	815	86
83	825	87
84	835	88
85	845	89
86	855	90
87	865	91
88	875	92
89	885	93
90	895	94
91	905	95
92	915	96
93	925	97
94	935	98
95	945	99
96	955	100
97	965	101
98	975	102
99	985	103
100	995	104
200	1989	209
300	2983	313

M.	7 d	83 d
1	10	1
2	20	2
3	30	4
4	40	5
5	50	6
6	60	7
7	69	8
8	79	10
9	89	11
10	99	12
11	109	13
12	119	15
13	129	16
14	139	17
15	149	18
16	159	20
17	169	21
18	179	22
19	189	23
20	199	24
21	208	26
22	218	27
23	228	28
24	238	29
25	248	30
26	258	32
27	268	33
28	278	34
29	288	35
30	298	37
31	308	38
32	318	39
33	327	40
34	337	41

M.	7 d.	83 d.
35	347	43
36	357	44
37	367	45
38	377	46
39	387	48
40	397	49
41	407	50
42	417	51
43	427	52
44	437	54
45	447	55
46	456	56
47	466	57
48	476	59
49	486	60
50	496	61
51	506	62
52	516	63
53	526	65
54	536	66
55	546	67
56	556	68
57	566	69
58	576	71
59	586	72
60	596	73
61	605	74
62	615	76
63	625	77
64	635	78
65	645	79
66	655	81
67	665	82
68	675	83

Min.	7 d.	83 d.
69	685	84
70	695	85
71	705	87
72	715	88
73	725	89
74	734	90
75	744	92
76	754	93
77	764	94
78	774	95
79	784	96
80	794	98
81	804	99
82	814	100
83	824	101
84	834	103
85	844	104
86	854	105
87	863	106
88	873	107
89	883	109
90	893	110
91	903	111
92	913	112
93	923	113
94	933	115
95	943	116
96	953	117
97	963	118
98	973	120
99	983	121
100	993	122
200	1985	244
300	2977	366

M.	8 d.	82 d.	M	8 d.	82 d.	Min.	8 d.	82 d.
1	10	1	35	347	49	69	683	96
2	20	3	36	357	50	70	693	97
3	30	4	37	366	51	71	703	99
4	40	6	38	376	53	72	713	100
5	50	7	39	386	54	73	723	102
6	59	8	40	396	56	74	733	103
7	69	10	41	406	57	75	743	104
8	79	11	42	416	58	76	753	106
9	89	13	43	426	60	77	763	107
10	99	14	44	436	61	78	772	109
11	109	15	45	446	63	79	782	110
12	119	17	46	456	64	80	792	111
13	129	18	47	465	65	81	802	113
14	139	19	48	475	67	82	812	114
15	148	21	49	485	68	83	822	115
16	158	22	50	495	70	84	832	117
17	168	24	51	505	71	85	842	118
18	178	25	52	515	72	86	852	120
19	188	26	53	525	74	87	862	121
20	198	28	54	535	75	88	872	122
21	208	29	55	545	77	89	881	124
22	218	31	56	555	78	90	891	125
23	228	32	57	565	79	91	901	127
24	238	33	58	574	81	92	911	128
25	248	35	59	584	82	93	921	129
26	257	36	60	594	83	94	931	131
27	267	38	61	604	85	95	941	132
28	277	39	62	614	86	96	951	134
29	287	40	63	624	88	97	961	135
30	297	42	64	634	89	98	970	136
31	307	43	65	644	90	99	980	138
32	317	44	66	654	92	100	990	139
33	327	46	67	664	93	200	1981	278
34	337	47	68	673	95	300	2971	418

M.	9 d.	81 d.	M.	9 d.	81 d.	Min.	9 d.	81 d.
1	10	2	35	346	55	69	682	108
2	20	3	36	356	56	70	691	109
3	30	5	37	366	58	71	701	111
4	40	6	38	375	59	72	711	112
5	49	8	39	385	61	73	721	114
6	59	9	40	395	63	74	731	116
7	69	11	41	405	94	75	741	117
8	79	13	42	415	66	76	751	119
9	89	14	43	425	67	77	761	120
10	99	16	44	435	69	78	770	122
11	109	17	45	445	70	79	780	124
12	119	19	46	454	72	80	790	125
13	129	20	47	464	73	81	800	127
14	138	22	48	474	75	82	810	128
15	148	23	49	484	77	83	820	130
16	158	25	50	494	78	84	830	131
17	168	26	51	504	80	85	840	133
18	178	28	52	514	81	86	850	134
19	188	30	53	524	83	87	859	136
20	198	31	54	534	84	88	869	138
21	208	33	55	543	86	89	879	139
22	217	34	56	553	88	90	889	141
23	227	36	57	563	89	91	899	142
24	237	37	58	573	91	92	909	144
25	247	39	59	583	92	93	919	145
26	257	41	60	593	94	94	929	147
27	267	42	61	603	95	95	938	148
28	277	44	62	612	97	96	948	150
29	287	45	63	622	98	97	958	152
30	296	47	64	632	100	98	968	153
31	306	48	65	642	102	99	978	155
32	316	50	66	652	103	100	988	156
33	326	51	67	662	105	200	1975	213
34	336	53	68	672	106	300	2963	369

M.	10d.	80d.	M.	10d.	80d.	Min.	10d.	80d.
1	10	2	35	345	61	69	680	120
2	20	3	36	355	62	70	689	121
3	30	5	37	365	64	71	699	123
4	39	7	38	374	66	72	709	125
5	49	9	39	384	68	73	719	127
6	59	10	40	394	69	74	729	128
7	69	12	41	404	71	75	739	130
8	79	14	42	414	73	76	749	132
9	89	16	43	424	57	77	758	133
10	99	17	44	433	76	78	768	135
11	108	19	45	443	78	79	778	137
12	118	21	46	453	80	80	788	139
13	128	23	47	463	81	81	798	141
14	138	24	48	473	83	82	808	142
15	148	26	49	483	85	83	817	144
16	158	28	50	492	87	84	827	146
17	168	30	51	502	88	85	837	148
18	177	31	52	512	90	86	247	149
19	187	33	53	522	92	87	857	151
20	197	35	54	532	94	88	467	153
21	207	36	55	542	95	89	876	154
22	217	38	56	552	97	90	886	156
23	227	40	57	561	99	91	896	158
24	236	42	58	571	101	92	906	160
25	246	43	59	581	102	93	916	161
26	256	45	60	591	104	94	926	163
27	266	47	61	601	106	95	936	165
28	276	49	62	611	108	96	946	167
29	286	50	63	520	109	97	955	168
30	296	52	64	630	111	88	965	170
31	305	54	65	640	113	99	975	172
32	315	55	66	650	115	100	985	174
33	325	57	67	660	116	200	1970	347
34	335	59	68	670	118	300	2954	521

M.	11d.	79d.	M.	11d.	79d.	Min.	11d.	79d.
1	10	2	35	343	67	69	677	132
2	20	4	36	353	69	70	687	134
3	29	6	37	363	71	71	697	135
4	39	8	38	373	72	72	707	137
5	49	9	39	383	54	73	716	139
6	59	11	40	393	76	74	726	141
7	69	13	41	402	78	75	736	143
8	78	15	42	412	80	76	746	145
9	88	17	43	422	82	77	756	147
10	98	19	44	432	84	78	765	149
11	108	21	45	442	86	79	775	151
12	118	23	46	452	88	80	785	153
13	128	25	47	461	90	81	795	154
14	137	27	48	471	92	82	805	156
15	147	29	49	481	93	83	815	158
16	157	30	50	491	95	84	824	160
17	167	32	51	501	97	85	834	162
18	177	34	52	510	99	86	844	164
19	186	36	53	520	101	87	854	166
20	196	38	54	530	103	88	864	168
21	206	40	55	540	105	89	873	170
22	216	42	56	550	107	90	883	172
23	226	44	57	559	109	91	893	174
24	236	46	58	569	111	92	903	176
25	245	48	59	579	112	93	913	177
26	255	50	60	589	114	94	923	179
27	265	51	61	599	116	95	932	181
28	275	53	62	609	118	96	942	183
29	285	55	63	618	120	97	952	185
30	294	57	64	628	122	98	962	187
31	304	59	65	638	124	99	972	189
32	314	61	66	648	126	100	981	191
33	324	63	67	658	128	200	1963	382
34	334	65	68	668	130	300	2944	572

M.	12d	78d
1	10	2
2	20	4
3	29	6
4	39	8
5	49	10
6	59	12
7	68	15
8	78	17
9	88	19
10	98	21
11	108	23
12	117	25
13	127	27
14	137	29
15	147	31
16	156	33
17	166	36
18	176	38
19	186	40
20	196	42
21	205	44
22	215	46
23	225	48
24	235	50
25	245	52
26	254	54
27	264	56
28	274	58
29	284	60
30	293	62
31	303	64
32	313	66
33	323	69
34	333	71
35	342	73
36	352	75
37	362	77
38	372	79
39	381	81
40	391	83
41	401	85
42	411	87
43	420	90
44	430	92
45	440	94
46	450	96
47	460	98
48	470	100
49	479	102
50	489	104
51	499	106
52	509	108
53	518	110
54	528	112
55	538	114
56	548	116
57	558	118
58	567	121
59	577	123
60	587	125
61	597	127
62	607	129
63	616	131
64	626	133
65	636	135
66	646	137
67	655	140
68	665	142

Min.	12 d.	78 d
69	675	144
70	685	146
71	694	148
72	704	150
73	714	152
74	724	154
75	734	156
76	743	158
77	753	160
78	763	162
79	773	164
80	783	166
81	792	168
82	802	170
83	812	173
84	822	175
85	831	177
86	841	179
87	851	181
88	861	183
89	871	185
90	880	187
91	890	189
92	900	191
93	910	193
94	920	195
95	929	197
96	939	200
97	949	202
98	959	204
99	968	206
100	978	208
200	1956	416
300	2934	624

M.	13d	77d
1	10	2
2	20	4
3	29	7
4	39	9
5	49	11
6	59	13
7	68	16
8	78	18
9	88	20
10	98	22
11	107	25
12	117	27
13	127	29
14	136	31
15	146	34
16	156	36
17	166	38
18	176	40
19	185	43
20	195	45
21	205	47
22	215	49
23	224	52
24	234	54
25	244	56
26	254	58
27	263	61
28	273	63
29	283	65
30	292	67
31	302	70
32	312	72
33	322	74
34	331	76

M.	13d.	77d.
35	341	79
36	351	81
37	361	83
38	370	86
39	380	88
40	390	90
41	400	92
42	409	94
43	419	97
44	429	99
45	438	101
46	448	103
47	458	106
48	468	108
49	477	110
50	487	112
51	497	115
52	507	117
53	516	119
54	526	121
55	536	124
56	546	126
57	555	128
58	565	130
59	575	133
60	585	135
61	594	137
62	604	140
63	614	142
64	624	144
65	634	146
66	643	148
67	653	151
68	663	153

Min.	13 d.	77 d.
69	672	155
70	682	157
71	692	160
72	702	162
73	711	164
74	721	166
75	731	169
76	741	171
77	750	173
78	760	175
79	770	178
80	780	180
81	789	182
82	799	184
83	809	187
84	818	189
85	828	191
86	838	193
87	848	196
88	857	198
89	867	200
90	877	202
91	887	205
92	896	207
93	906	209
94	916	211
95	926	214
96	935	216
97	945	218
98	955	221
99	965	223
100	974	225
200	1949	450
300	2923	675

M	14d.	76d.
1	10	2
2	19	5
3	29	7
4	39	10
5	48	12
6	58	14
7	68	17
8	78	19
9	87	22
10	97	24
11	107	27
12	116	29
13	126	31
14	136	34
15	146	36
16	155	39
17	165	41
18	175	44
19	184	46
20	194	48
21	204	51
22	213	53
23	223	56
24	233	58
25	242	60
26	252	63
27	262	65
28	272	68
29	281	70
30	291	73
31	301	75
32	310	77
33	320	80
34	330	82

M.	14d.	76d.
35	340	85
36	349	87
37	359	90
38	369	92
39	378	94
40	388	97
41	398	99
42	407	102
43	417	104
44	427	107
45	437	109
46	446	111
47	456	114
48	466	116
49	475	119
50	485	121
51	495	123
52	504	126
53	514	128
54	524	131
55	534	133
56	543	136
57	553	138
58	563	140
59	572	143
60	582	145
61	592	148
62	601	150
63	611	153
64	621	155
65	631	157
66	640	160
67	650	162
68	660	165

Min.	14 d.	76 d.
69	669	167
70	679	169
71	689	172
72	698	174
73	708	177
74	718	179
75	728	182
76	737	184
77	747	187
78	757	189
79	766	191
80	776	194
81	786	195
82	796	197
83	805	200
84	815	202
85	825	205
86	834	207
87	844	209
88	854	213
89	864	215
90	873	218
91	883	220
92	893	223
93	902	225
94	911	227
95	921	230
96	931	232
97	941	235
98	951	237
99	960	240
100	970	242
200	1941	484
300	2911	726

M.	15 d	75 d	M	15 d	75 d	Min.	15 d.	75 a
1	10	3	35	338	91	69	666	179
2	19	5	36	348	93	70	676	181
3	29	8	37	357	96	71	686	184
4	39	10	38	367	98	72	696	186
5	48	13	39	377	101	73	705	189
6	58	16	40	386	103	74	715	192
7	68	18	41	396	106	75	724	194
8	77	21	42	406	109	76	734	197
9	87	23	43	415	111	77	744	200
10	97	26	44	425	114	78	754	202
11	106	28	45	435	116	79	763	205
12	116	31	46	444	119	80	773	207
13	126	34	47	454	123	81	783	210
14	135	36	48	464	125	82	792	212
15	145	39	49	473	128	83	802	215
16	155	41	50	483	129	84	811	217
17	164	44	51	493	132	85	821	220
18	174	47	52	502	135	86	831	223
19	183	49	53	512	137	87	840	225
20	193	52	54	522	140	88	850	228
21	203	54	55	531	142	89	860	230
22	213	57	56	541	145	90	869	233
23	222	60	57	551	148	91	879	236
24	233	62	58	560	150	92	889	238
25	242	65	59	570	153	93	898	241
26	251	67	60	580	155	94	908	243
27	261	70	61	589	158	95	918	246
28	271	73	62	599	160	96	927	248
29	280	75	63	608	163	97	937	251
30	290	78	64	618	166	98	947	254
31	299	80	65	628	168	99	956	256
32	309	83	66	638	171	100	966	259
33	319	85	67	647	174	200	1932	518
34	328	88	68	657	176	300	2898	776

M.	16d.	74d
1	10	3
2	19	6
3	29	8
4	38	11
5	48	14
6	58	17
7	67	19
8	77	22
9	86	25
10	96	28
11	106	30
12	115	33
13	125	36
14	134	39
15	144	41
16	154	44
17	163	47
18	173	50
19	183	53
20	192	55
21	202	58
22	211	61
23	222	63
24	231	66
25	240	69
26	250	72
27	259	75
28	269	77
29	279	80
30	288	83
31	298	85
32	308	88
33	317	91
34	327	94

M.	16d.	74d.
35	336	97
36	346	99
37	356	102
38	365	105
39	375	107
40	384	110
41	394	113
42	404	116
43	413	119
44	423	121
45	432	124
46	442	127
47	452	130
48	461	132
49	471	135
50	481	138
51	490	141
52	500	143
53	509	146
54	519	149
55	529	151
56	538	154
57	548	157
58	557	160
59	567	163
60	577	165
61	586	168
62	596	171
63	606	174
64	615	177
65	625	179
66	634	182
67	644	185
68	654	188

Min.	16 d.	74 d.
69	663	190
70	673	193
71	682	196
72	692	199
73	702	201
74	711	204
75	721	207
76	731	210
77	740	213
78	750	215
79	759	218
80	769	220
81	779	223
82	788	226
83	798	229
84	807	232
85	817	235
86	827	237
87	836	240
88	846	243
89	856	245
90	865	248
91	875	251
92	884	254
93	894	257
94	904	259
95	913	262
96	923	265
97	932	267
98	942	270
99	952	273
100	961	276
200	1923	551
300	2884	827

M.	17d.	73d.	M.	17d.	73d	Min.	17 d.	73 d.
1	10	3	35	335	102	69	660	202
2	19	6	36	344	105	70	669	205
3	29	9	37	354	108	71	679	207
4	38	12	38	363	111	72	688	210
5	48	15	39	373	114	73	698	213
6	57	17	40	383	117	74	708	216
7	67	20	41	392	120	75	717	219
8	76	23	42	402	123	76	727	222
9	86	26	43	411	126	77	736	225
10	96	29	44	421	129	78	746	228
11	105	32	45	430	131	79	755	231
12	115	35	46	440	134	80	765	234
13	124	38	47	449	137	81	775	237
14	134	41	48	459	140	82	784	240
15	143	44	49	469	143	83	794	243
16	153	47	50	478	146	84	803	246
17	162	50	51	488	149	85	813	248
18	172	52	52	497	152	86	822	251
19	182	55	53	507	155	87	832	254
20	191	58	54	516	158	88	842	257
21	201	61	55	526	161	89	851	260
22	210	64	56	535	164	90	861	263
23	220	67	57	545	167	91	870	266
24	230	70	58	554	170	92	880	269
25	239	73	59	564	172	93	889	272
26	249	76	60	574	175	94	899	275
27	258	79	61	583	178	95	908	278
28	268	82	62	593	181	96	918	281
29	277	85	63	602	184	97	927	284
30	287	88	64	612	187	98	937	287
31	296	91	65	622	190	99	947	289
32	306	93	66	631	193	100	956	292
33	316	96	67	641	196	200	1913	585
34	325	99	68	650	199	300	2869	877

M.	18d.	72d.	M.	18d.	72d.	Min.	18d.	72d.
1	10	3	35	333	108	69	656	213
2	19	6	36	342	111	70	666	216
3	28	9	37	352	114	71	675	219
4	38	12	38	361	117	72	685	222
5	47	15	39	371	120	73	694	225
6	57	18	40	380	124	74	704	229
7	66	22	41	390	127	75	713	232
8	76	25	42	398	130	76	723	235
9	85	28	43	408	133	77	732	238
10	95	31	44	417	136	78	742	241
11	104	34	45	427	139	79	751	244
12	114	37	46	436	142	80	761	247
13	123	40	47	446	145	81	770	250
14	133	43	48	455	148	82	780	253
15	142	46	49	465	151	83	789	256
16	152	50	50	476	154	84	799	260
17	161	53	51	485	158	85	808	263
18	171	56	52	495	161	86	818	266
19	180	59	53	504	164	87	827	269
20	190	62	54	514	167	88	837	272
21	200	65	55	523	170	89	846	275
22	209	68	56	533	173	90	856	278
23	219	71	57	542	176	91	865	281
24	228	74	58	552	179	92	875	284
25	238	77	59	561	182	93	884	287
26	247	81	60	571	185	94	894	290
27	257	84	61	580	188	95	903	293
28	266	87	62	596	192	96	913	297
29	276	90	63	599	195	97	922	300
30	285	93	64	609	198	88	932	303
31	295	96	65	618	201	99	941	306
32	304	99	66	628	204	100	951	309
33	314	102	67	637	207	200	1902	618
34	323	105	68	647	210	300	2850	927

M.	19d	71d.
1	9	3
2	19	6
3	28	10
4	38	13
5	47	16
6	57	20
7	66	23
8	75	26
9	85	29
10	94	33
11	104	36
12	113	39
13	123	42
14	132	46
15	142	49
16	151	52
17	161	55
18	170	59
19	180	62
20	189	65
21	199	68
22	208	72
23	217	75
24	227	78
25	236	82
26	246	85
27	255	88
28	265	91
29	274	94
30	284	98
31	293	101
32	303	104
33	312	107
34	321	111

M.	19d	71d.
35	331	114
36	340	117
37	350	121
38	359	124
39	369	127
40	378	130
41	388	134
42	397	137
43	407	140
44	416	143
45	425	147
46	435	150
47	444	153
48	454	156
49	463	160
50	473	163
51	482	166
52	492	169
53	501	173
54	510	176
55	520	179
56	539	182
57	549	186
58	558	189
59	567	192
60	577	195
61	586	199
62	596	202
63	605	205
64	615	308
65	624	212
66	634	215
67	644	218
68	653	222

Min.	19 d.	71 d.
69	652	225
70	662	228
71	671	231
72	681	234
73	690	238
74	699	241
75	709	244
76	718	247
77	728	251
78	737	254
79	747	257
80	756	261
81	766	264
82	775	267
83	785	270
84	794	274
85	804	277
86	813	280
87	822	283
88	832	287
89	841	290
90	851	293
91	860	296
92	870	300
93	879	303
94	889	306
95	898	309
96	908	313
97	917	516
98	926	319
99	936	322
100	945	326
200	1891	651
300	2836	977

M.	20 d.	70 d.
1	9	3
2	19	7
3	28	10
4	38	14
5	47	17
6	56	20
7	66	24
8	75	27
9	85	31
10	94	34
11	103	38
12	113	41
13	122	44
14	132	48
15	141	51
16	150	55
17	160	58
18	169	61
19	179	65
20	188	68
21	197	72
22	207	75
23	216	79
24	226	82
25	235	85
26	244	89
27	254	92
28	263	96
29	272	100
30	282	103
31	291	106
32	301	109
33	310	113
34	319	116

M.	20 d.	70 d.
35	329	120
36	338	123
37	348	126
38	357	130
39	366	133
40	376	137
41	385	140
42	395	144
43	404	147
44	413	150
45	423	154
46	432	157
47	442	161
48	451	164
49	460	168
50	470	171
51	479	174
52	489	178
53	498	181
54	507	185
55	517	188
56	526	191
57	536	195
58	545	198
59	554	202
60	564	205
61	573	209
62	583	212
63	592	215
64	601	219
65	611	222
66	620	226
67	630	229
68	639	233

Min.	20 d.	70 d.
69	648	236
70	658	239
71	667	243
72	677	246
73	686	250
74	695	253
75	705	256
76	714	260
77	724	263
78	733	267
79	742	270
80	752	274
81	761	277
82	771	280
83	780	284
84	789	287
85	800	291
86	808	294
87	818	298
88	827	301
89	836	304
90	846	308
91	855	311
92	864	315
93	874	318
94	883	321
95	893	325
96	902	328
97	912	332
98	921	335
99	930	339
100	940	342
200	1879	684
300	2819	1026

M.	21d.	69d.	M.	21d.	69d.	Min.	21d.	69 d.
1	9	4	35	327	125	69	644	247
2	19	7	36	336	129	70	653	251
3	28	11	37	345	132	71	663	254
4	37	14	38	355	136	72	672	258
5	47	18	39	364	140	73	681	262
6	56	21	40	373	143	74	691	265
7	65	25	41	383	147	75	700	269
8	75	29	42	392	150	76	709	272
9	84	32	43	401	154	77	719	276
10	93	36	44	411	158	78	728	279
11	103	39	45	420	161	79	737	283
12	112	43	46	429	165	80	747	287
13	121	47	47	439	168	81	756	290
14	131	50	48	448	172	82	766	294
15	140	54	49	457	176	83	775	297
16	149	57	50	467	179	84	784	301
17	159	61	51	476	183	85	794	305
18	168	64	52	485	186	86	803	308
19	177	68	53	495	190	87	812	312
20	187	72	54	504	193	88	822	315
21	196	75	55	513	197	89	831	319
22	205	79	56	523	201	90	840	323
23	215	82	57	532	204	91	849	326
24	224	86	58	541	208	92	859	330
25	233	90	59	551	211	93	868	333
26	243	93	60	560	215	94	877	337
27	252	97	61	569	219	95	887	340
28	261	100	62	579	222	96	896	344
29	271	104	63	588	226	97	905	348
30	280	107	64	598	229	98	915	351
31	289	111	65	607	233	99	924	355
32	299	115	66	616	236	100	934	358
33	308	118	67	626	240	200	1867	717
34	317	122	68	635	244	300	1801	1075

M.	22d.	68d.
1	9	4
2	19	7
3	28	11
4	37	15
5	46	19
6	56	22
7	65	26
8	74	30
9	83	34
10	93	37
11	102	41
12	111	45
13	120	49
14	130	52
15	139	56
16	148	60
17	157	64
18	167	67
19	176	71
20	185	75
21	195	79
22	204	82
23	213	86
24	222	90
25	232	94
26	241	97
27	250	101
28	260	105
29	269	109
30	278	112
31	287	116
32	297	120
33	306	124
34	315	127

M.	22d.	68d.
35	324	131
36	334	135
37	343	139
38	352	142
39	361	146
40	371	150
41	380	154
42	389	157
43	399	161
44	408	165
45	417	169
46	426	172
47	436	176
48	445	180
49	454	184
50	464	187
51	473	191
52	482	195
53	491	199
54	501	202
55	510	206
56	519	210
57	529	214
58	538	217
59	547	221
60	556	225
61	566	229
62	575	232
63	584	236
64	594	240
65	603	244
66	612	247
67	621	251
68	631	255

Min.	22d.	68d.
69	640	259
70	649	262
71	658	266
72	667	270
73	677	274
74	686	276
75	695	281
76	705	285
77	714	289
78	723	292
79	733	296
80	742	300
81	751	304
82	760	307
83	770	311
84	779	315
85	788	319
86	797	322
87	806	326
88	816	330
89	825	334
90	834	337
91	844	341
92	853	345
93	862	349
94	871	352
95	881	356
96	890	360
97	899	364
98	909	367
99	918	371
100	927	375
200	1854	749
300	2782	1091

M.	23d.	67d	M.	23d.	67d.	Min.	23 d.	67 d.
1	9	4	35	322	137	69	635	296
2	18	8	36	331	141	70	644	273
3	28	12	37	340	144	71	653	277
4	37	16	38	350	148	72	663	281
5	46	19	39	359	152	73	672	285
6	55	23	40	368	156	74	681	289
7	64	27	41	377	160	75	690	293
8	74	31	42	386	164	76	699	297
9	83	35	43	396	168	77	709	301
10	92	39	44	405	172	78	718	305
11	101	43	45	414	176	79	727	308
12	110	47	46	423	180	80	736	312
13	120	51	47	433	184	81	746	316
14	129	55	48	442	187	82	755	320
15	138	59	49	451	191	83	764	324
16	147	62	50	460	195	84	773	328
17	156	66	51	469	199	85	782	332
18	166	70	52	479	203	86	792	336
19	175	74	53	488	207	87	801	340
20	184	78	54	497	211	88	810	344
21	193	82	55	506	215	89	819	348
22	202	86	56	515	219	90	828	352
23	212	90	57	524	223	91	838	356
24	221	94	58	534	226	92	847	360
25	230	98	59	543	230	93	856	363
26	239	102	60	552	234	94	865	367
27	248	105	61	561	238	95	874	370
28	258	109	62	571	242	96	884	375
29	267	113	63	580	246	97	893	379
30	276	117	64	589	250	98	902	383
31	285	121	65	598	254	99	911	387
32	294	125	66	608	258	100	920	391
33	304	129	67	618	262	200	1841	781
34	313	133	68	626	266	300	1761	2172

M	24d	66d
1	9	4
2	18	8
3	27	12
4	36	16
5	46	20
6	55	24
7	64	28
8	73	32
9	82	37
10	91	41
11	100	45
12	109	49
13	119	53
14	128	57
15	137	61
16	146	65
17	155	69
18	164	73
19	173	77
20	183	81
21	192	85
22	201	90
23	210	94
24	219	98
25	228	102
26	237	106
27	246	110
28	256	113
29	265	117
30	274	122
31	283	126
32	292	130
33	301	134
34	310	138

M.	24d.	66d
35	320	142
36	329	146
37	338	151
38	347	155
39	356	159
40	365	163
41	374	167
42	384	171
43	393	175
44	402	179
45	411	183
46	420	187
47	429	191
48	438	195
49	448	199
50	457	203
51	466	207
52	475	211
53	484	216
54	493	220
55	502	224
56	511	228
57	521	232
58	530	236
59	539	240
60	548	244
61	557	248
62	566	252
63	575	256
64	585	260
65	594	264
66	603	268
67	612	272
68	621	276

Min.	24 d	66 d.
69	630	281
70	639	285
71	648	289
72	658	293
73	667	297
74	676	301
75	685	305
76	694	309
77	703	313
78	712	317
79	721	321
80	731	325
81	740	329
82	749	333
83	758	337
84	767	341
85	776	345
86	785	349
87	795	353
88	804	357
89	813	362
90	822	366
91	831	370
92	840	374
93	849	378
94	858	382
95	868	386
96	877	390
97	886	395
98	895	399
99	904	403
100	913	407
200	1827	813
300	2740	1220

M	25d	65d
1	9	4
2	18	8
3	27	13
4	36	17
5	45	21
6	54	25
7	63	30
8	72	34
9	81	38
10	91	42
11	100	47
12	109	51
13	118	55
14	127	59
15	136	63
16	145	68
17	154	72
18	163	76
19	172	80
20	181	84
21	190	89
22	199	93
23	208	97
24	218	101
25	227	106
26	236	110
27	245	114
28	254	118
29	263	123
30	272	127
31	281	131
32	290	135
33	299	140
34	308	144

M.	25d.	65d.
35	317	148
36	326	152
37	335	156
38	344	161
39	353	165
40	362	169
41	372	173
42	381	178
43	390	182
44	399	186
45	408	190
46	417	195
47	426	199
48	435	203
49	444	207
50	453	211
51	462	216
52	471	220
53	480	224
54	489	228
55	498	332
56	507	237
57	516	241
58	526	245
59	535	250
60	544	254
61	553	258
62	562	262
63	571	267
64	580	271
65	589	275
66	598	279
67	607	283
68	616	288

Min.	25 d.	65 d.
69	625	292
70	634	296
71	643	300
72	652	305
73	662	309
74	671	313
75	680	317
76	689	321
77	698	326
78	707	330
79	716	334
80	725	338
81	734	343
82	743	347
83	752	351
84	761	355
85	770	360
86	779	364
87	788	368
88	797	372
89	807	376
90	816	380
91	825	384
92	834	389
93	843	393
94	852	397
95	861	401
96	870	406
97	879	410
98	888	414
99	897	418
100	906	423
200	1813	845
300	2719	1268

M.	26d.	64d.	M.	26d.	64d.	Min.	26d.	64 d.
1	9	4	35	315	153	69	620	302
2	18	9	36	324	158	70	629	307
3	27	13	37	333	162	71	638	311
4	36	18	38	342	166	72	647	316
5	45	22	39	351	171	73	656	320
6	54	26	40	360	175	74	665	324
7	63	31	41	368	179	75	674	329
8	72	35	42	378	184	76	683	333
9	81	39	43	386	188	77	692	338
10	90	44	44	395	193	78	701	342
11	99	48	45	404	197	79	710	346
12	108	53	46	413	202	80	719	351
13	117	57	47	422	206	81	728	355
14	126	61	48	431	210	82	737	359
15	135	66	49	440	214	83	746	364
16	144	70	50	449	219	84	755	368
17	153	74	51	458	223	85	764	372
18	162	79	52	467	228	86	773	377
19	171	83	53	476	232	87	782	381
20	180	88	54	485	237	88	791	385
21	189	92	55	494	241	89	800	390
22	198	96	56	503	245	90	809	394
23	207	101	57	512	250	91	818	399
24	216	105	58	521	254	92	827	403
25	225	109	59	530	258	93	836	407
26	234	114	60	539	263	94	845	412
27	243	118	61	548	267	95	854	416
28	252	123	62	557	272	96	863	421
29	261	127	63	566	276	97	872	425
30	270	131	64	575	280	98	881	429
31	279	136	65	584	285	99	890	434
32	288	140	66	593	289	100	899	438
33	297	144	67	602	294	200	1798	877
34	306	149	68	611	298	300	2696	1315

M.	27d	63d.	M	27d.	63d.	Min.	27 d.	63 d.
1	9	5	35	312	159	69	615	313
2	18	9	36	321	163	70	624	318
3	27	14	37	330	168	71	633	322
4	36	18	38	338	172	72	641	327
5	45	23	39	347	177	73	650	332
6	53	27	40	356	182	74	659	336
7	62	32	41	365	186	75	668	341
8	71	36	42	374	191	76	677	345
9	80	41	43	383	195	77	686	350
10	89	45	44	391	200	78	695	354
11	98	50	45	401	204	79	704	359
12	107	54	46	410	209	80	713	363
13	116	59	47	419	213	81	722	368
14	125	63	48	428	218	82	731	372
15	134	68	49	436	222	83	739	377
16	143	72	50	445	227	84	748	381
17	151	77	51	454	232	85	757	386
18	160	82	52	463	236	86	766	390
19	169	86	53	472	241	87	775	495
20	178	91	54	481	245	88	784	400
21	187	95	55	490	250	89	793	404
22	196	100	56	499	254	90	802	409
23	205	104	57	508	259	91	811	413
24	214	109	58	517	263	92	820	418
25	223	113	59	526	268	93	829	422
26	232	118	60	535	272	94	837	427
27	241	122	61	543	277	95	846	431
28	349	127	62	552	282	96	855	436
29	258	132	63	561	286	97	864	440
30	267	136	64	570	291	98	873	445
31	276	141	65	579	295	99	882	449
32	285	145	66	588	300	100	891	454
33	294	150	67	597	304	200	1782	909
34	303	154	68	606	309	300	2673	1363

M.	28 d.	62 d.
1	9	5
2	18	9
3	26	14
4	35	19
5	44	23
6	53	28
7	62	33
8	71	37
9	79	42
10	88	47
11	97	52
12	106	56
13	115	61
14	124	66
15	132	70
16	141	75
17	150	80
18	159	84
19	168	89
20	177	94
21	185	99
22	194	103
23	203	108
24	212	113
25	221	117
26	230	122
27	238	127
28	247	131
29	256	136
30	265	141
31	274	145
32	282	150
33	291	155
34	300	160

M.	28 d.	62 d.
35	309	164
36	318	169
37	326	174
38	335	178
39	344	183
40	353	188
41	362	192
42	371	197
43	380	202
44	388	207
45	397	211
46	406	216
47	415	221
48	424	225
49	432	330
50	441	235
51	450	239
52	459	244
53	468	249
54	477	254
55	485	258
56	494	263
57	503	268
58	512	272
59	521	277
60	530	282
61	528	286
62	547	291
63	556	296
64	565	300
65	574	305
66	583	310
67	591	315
68	600	319

Min.	28 d.	62 d.
69	609	324
70	618	329
71	627	333
72	636	338
73	644	343
74	653	347
75	662	352
76	671	357
77	680	361
78	689	366
79	697	371
80	706	376
81	715	380
82	724	385
83	733	390
84	742	394
85	750	399
86	759	404
87	768	408
88	777	413
89	786	418
90	795	422
91	803	427
9	812	432
93	821	437
94	830	441
95	839	446
96	848	451
97	856	455
98	865	460
99	874	465
100	883	469
200	1766	939
300	2640	1408

M.	29d.	61d.	M.	29d.	61d.	Min.	29d.	61d.
1	9	5	35	306	170	69	604	334
2	17	10	36	315	174	70	612	339
3	26	14	37	324	179	71	621	344
4	35	19	38	332	184	72	630	349
5	44	24	39	341	189	73	638	354
6	52	29	40	350	194	74	647	359
7	61	34	41	359	199	75	656	363
8	70	39	42	367	203	76	665	368
9	79	43	43	376	208	77	673	373
10	87	48	44	385	213	78	682	378
11	96	53	45	394	218	79	691	383
12	105	58	46	402	223	80	700	388
13	114	63	47	411	228	81	708	393
14	122	68	48	420	233	82	717	397
15	131	73	49	429	237	83	726	402
16	140	77	50	437	242	84	735	407
17	149	82	51	446	247	85	743	412
18	157	87	52	455	252	86	752	417
19	166	92	53	464	257	87	761	422
20	175	97	54	472	262	88	770	427
21	184	102	55	481	267	89	778	431
22	192	107	56	490	271	90	787	436
23	201	111	57	499	276	91	796	441
24	210	116	58	507	281	92	805	446
25	219	121	59	516	286	93	813	451
26	227	126	60	525	291	94	822	456
27	236	131	61	534	296	95	831	461
28	245	136	62	542	301	96	840	465
29	254	141	63	551	305	97	848	470
30	262	145	64	560	310	98	857	475
31	271	150	65	569	315	99	866	480
32	280	155	66	577	320	100	875	485
33	289	160	67	586	325	200	1749	970
34	297	165	68	595	330	300	2624	1454

M.	30d.	60d.	M.	30d.	60d.	Min.	30d.	60d.
1	9	5	35	303	175	69	598	345
2	17	10	36	312	180	70	606	350
3	26	15	37	320	185	71	615	355
4	35	20	38	329	190	72	623	360
5	43	25	39	338	195	73	632	365
6	52	30	40	346	200	74	641	370
7	61	35	41	355	205	75	649	375
8	69	40	42	364	210	76	658	380
9	78	45	43	372	215	77	667	385
10	87	50	44	381	220	78	676	390
11	95	55	45	390	225	79	684	395
12	104	60	46	398	230	80	693	400
13	113	65	47	407	235	81	702	405
14	121	70	48	416	240	82	710	410
15	130	75	49	424	245	83	719	415
16	139	80	50	433	250	84	727	420
17	147	85	51	442	255	85	736	425
18	156	90	52	450	260	86	745	430
19	165	95	53	459	265	87	753	435
20	173	100	54	468	270	88	762	440
21	182	105	55	476	275	89	771	445
22	191	110	56	485	280	90	779	450
23	199	115	57	494	285	91	788	455
24	208	120	58	502	290	92	797	460
25	217	125	59	511	295	93	806	465
26	225	130	60	520	300	94	814	470
27	234	135	61	528	305	95	823	475
28	242	140	62	537	310	96	832	480
29	251	145	63	546	315	97	840	485
30	260	150	64	554	320	88	849	490
31	268	155	65	563	325	99	857	495
32	277	160	66	572	330	100	866	500
33	286	165	67	580	335	200	1732	1000
34	294	170	68	589	340	300	2598	1500

M.	31 d.	59 d.	M.	31 d.	59 d.	Min.	31 d.	59 d.
1	9	5	35	300	180	69	591	355
2	17	10	36	309	185	70	600	360
3	26	15	37	317	191	71	609	366
4	34	21	38	326	196	72	617	371
5	43	26	39	334	201	73	626	376
6	51	31	40	343	206	74	634	381
7	60	36	41	351	211	75	643	386
8	69	41	42	360	216	76	651	391
9	77	46	43	369	221	77	660	397
10	86	51	44	377	227	78	669	402
11	94	57	45	386	232	79	677	407
12	103	62	46	394	237	80	686	412
13	111	67	47	403	242	81	694	417
14	120	72	48	411	247	82	703	422
15	129	77	49	420	252	83	711	427
16	137	82	50	429	257	84	720	433
17	146	88	51	437	263	85	729	438
18	154	93	52	446	268	86	737	443
19	163	98	53	454	273	87	746	448
20	171	103	54	463	278	88	754	453
21	180	108	55	471	283	89	763	458
22	189	113	56	480	288	90	771	463
23	197	118	57	489	294	91	780	469
24	206	124	58	497	299	92	789	474
25	214	129	59	506	304	93	797	479
26	223	134	60	514	309	94	806	484
27	231	139	61	523	314	95	814	489
28	240	144	62	531	319	96	723	494
29	249	149	63	540	324	97	831	500
30	257	154	64	549	330	98	840	505
31	266	160	65	557	335	99	849	510
32	274	165	66	566	340	100	857	515
33	283	170	67	574	345	200	1714	1030
34	292	175	68	583	350	300	2572	1545

M.	32d.	58d.	M.	32d.	58d.	Min.	32 d.	58 d.
1	8	5	35	297	185	69	585	366
2	17	11	36	305	191	70	594	371
3	25	16	37	314	196	71	602	376
4	34	21	38	322	201	72	610	381
5	42	26	39	331	207	73	619	387
6	51	32	40	339	212	74	627	392
7	59	37	41	348	217	75	636	397
8	68	42	42	356	223	76	644	403
9	76	48	43	365	228	77	653	408
10	85	53	44	373	233	78	661	413
11	93	58	45	382	238	79	670	419
12	102	64	46	390	244	80	678	424
13	110	69	47	398	249	81	687	429
14	119	74	48	407	254	82	695	434
15	127	79	49	415	260	83	703	440
16	136	85	50	424	265	84	712	445
17	144	90	51	432	270	85	721	450
18	153	95	52	441	275	86	729	456
19	161	101	53	449	281	87	738	461
20	170	106	54	458	286	88	746	466
21	178	111	55	466	291	89	755	472
12	187	117	56	475	297	90	763	477
23	195	122	57	483	302	91	772	482
24	204	127	58	492	307	92	780	487
25	212	132	59	500	313	93	788	493
26	220	138	60	509	318	94	797	498
27	229	143	61	517	323	95	805	503
28	237	148	62	526	329	96	814	509
29	246	153	63	534	334	97	822	514
30	254	159	64	543	339	98	831	519
31	263	164	05	551	344	99	839	524
32	271	170	66	560	350	100	848	530
33	280	175	67	568	355	200	1696	1060
34	288	180	68	577	360	300	2544	1590

M.	33 d.	57 d.	M.	33 d.	57 d.	Min.	33 d.	57 d.
1	8	5	35	294	191	69	579	376
2	17	11	36	302	196	70	587	381
3	25	16	37	311	202	71	596	386
4	34	22	38	319	307	72	604	392
5	42	27	39	327	212	73	612	397
6	50	33	40	335	218	74	621	403
7	59	38	41	344	223	75	629	408
8	67	44	42	352	229	76	637	414
9	76	49	43	361	234	77	646	419
10	84	54	44	369	240	78	654	425
11	92	60	45	377	245	79	663	430
12	101	65	46	386	251	80	671	436
13	109	71	47	394	256	81	679	441
14	117	76	48	403	262	82	688	446
15	126	82	49	411	267	83	696	452
16	134	87	50	419	272	84	705	457
17	143	93	51	428	278	85	713	462
18	151	98	52	436	283	86	721	468
19	159	104	53	445	288	87	730	473
20	168	109	54	453	294	88	738	479
21	176	114	55	461	300	89	747	884
22	185	120	56	470	305	90	755	490
23	193	125	57	478	310	91	763	495
24	201	131	58	487	316	92	772	501
25	210	136	59	495	321	93	780	506
26	218	142	60	503	327	94	789	512
27	227	147	61	512	332	95	797	517
28	235	153	62	520	338	96	805	522
29	243	158	63	529	343	97	814	528
30	252	163	64	537	348	98	822	533
31	260	169	65	545	354	99	831	539
32	269	174	66	554	355	100	839	545
33	277	180	67	562	365	200	1677	1089
34	285	185	68	571	370	300	2516	1634

M	34d	56d.
1	8	6
2	17	11
3	25	17
4	33	22
5	41	28
6	50	34
7	58	39
8	66	45
9	75	50
10	83	56
11	91	61
12	99	67
13	108	73
14	116	78
15	124	84
16	133	89
17	141	95
18	149	101
19	158	106
20	166	112
21	174	117
22	182	123
23	191	129
24	199	134
25	207	140
26	216	145
27	224	151
28	232	157
29	240	162
30	249	168
31	257	173
32	265	179
33	274	184
34	282	190

M.	34d.	56d.
35	290	196
36	298	201
37	307	207
38	315	212
39	323	218
40	332	224
41	340	229
42	348	235
43	356	240
44	365	246
45	373	251
46	381	257
47	390	263
48	398	269
49	406	274
50	414	280
51	423	285
52	431	291
53	439	296
54	448	302
55	456	307
56	464	313
57	473	319
58	481	324
59	489	330
60	497	335
61	506	341
62	514	346
63	522	352
64	530	358
65	539	363
66	547	369
67	555	374
68	564	380

Min.	34 d.	56 d.
69	572	386
70	580	391
71	583	397
72	597	403
73	605	408
74	613	414
75	622	419
76	630	425
77	638	431
78	647	436
79	655	442
80	663	447
81	671	453
82	680	458
83	688	464
84	696	470
85	705	475
86	713	481
87	721	486
88	729	492
89	738	498
90	746	503
91	754	509
92	763	514
93	771	520
94	779	526
95	788	531
96	796	537
97	804	542
98	812	548
99	821	554
100	829	559
200	1658	1118
300	2487	1678

M	35 d.	55 d.	M.	35 d.	55 d	Min.	35 d.	35 d.
1	8	6	35	286	201	69	565	396
2	17	11	36	295	206	70	573	402
3	25	17	37	303	212	71	582	407
4	33	23	38	311	218	72	590	413
5	41	29	39	319	224	73	598	419
6	49	34	40	328	229	74	606	425
7	57	40	41	336	235	75	615	430
8	66	46	42	344	241	76	623	436
9	74	52	43	352	246	77	631	442
10	82	57	44	360	252	78	639	448
11	90	63	45	368	258	79	647	453
12	98	69	46	377	264	80	655	459
13	106	75	47	385	270	81	664	465
14	115	80	48	393	275	82	672	470
15	123	86	49	401	281	83	680	476
16	131	92	50	410	287	84	688	482
17	139	98	51	418	292	85	696	488
18	147	103	52	426	298	86	705	493
19	156	109	53	434	504	87	713	499
20	164	115	54	442	310	88	721	505
21	172	120	55	451	315	89	729	511
22	180	126	56	459	321	90	737	516
23	188	132	57	467	327	91	746	522
24	196	138	58	475	333	92	754	528
25	205	143	59	483	338	93	762	534
26	213	149	60	491	344	94	770	539
27	221	155	61	500	350	95	778	545
28	229	161	62	508	356	96	786	551
29	237	166	63	516	361	97	795	556
30	246	172	64	524	367	98	803	562
31	254	178	65	533	373	99	811	568
32	262	184	66	541	379	100	819	574
33	270	189	67	549	384	200	1638	1147
34	278	195	68	557	390	300	2458	1721

M.	36d.	54d.
1	8	6
2	16	12
3	24	18
4	32	23
5	40	29
6	48	35
7	57	41
8	65	47
9	72	53
10	81	59
11	89	65
12	97	70
13	105	76
14	113	82
15	121	88
16	129	94
17	138	100
18	146	106
19	154	112
20	162	118
21	170	123
22	178	129
23	186	135
24	194	141
25	202	147
26	210	153
27	218	159
28	226	164
29	235	170
30	243	176
31	251	182
32	259	188
33	267	194
34	275	200

M.	36d.	54d.
35	283	206
36	291	211
37	299	217
38	307	223
39	315	229
40	324	235
41	332	241
42	340	247
43	348	253
44	356	258
45	364	264
46	372	270
47	380	276
48	388	282
49	396	288
50	404	294
51	413	300
52	421	306
53	429	311
54	437	317
55	445	323
56	453	329
57	461	335
58	469	341
59	477	347
60	485	353
61	493	358
62	502	364
63	510	370
64	518	376
65	526	382
66	534	388
67	542	394
68	550	400

Min.	36 d	54 d.
69	558	406
70	566	411
71	574	417
72	582	423
73	590	429
74	599	435
75	607	441
76	615	447
77	623	453
78	631	458
79	639	464
80	647	570
81	655	476
82	663	482
83	671	488
84	680	494
85	688	500
86	696	506
87	704	511
88	712	517
89	720	523
90	728	529
91	736	535
92	744	541
93	752	547
94	760	553
95	768	558
96	777	564
87	785	570
98	793	576
99	801	582
100	809	588
200	1618	1176
300	2427	1763

M.	37 d.	53 d.	M.	37 d.	53 d.	Min.	37 d.	53 d.
1	8	6	35	279	210	69	551	415
2	16	12	36	287	216	70	559	421
3	24	18	37	295	221	71	567	427
4	32	24	38	303	228	72	575	433
5	40	30	39	311	234	73	583	439
6	48	36	40	319	241	74	591	445
7	56	42	41	327	247	75	599	451
8	64	48	42	335	253	76	607	457
9	72	54	43	343	259	77	615	463
10	80	60	44	351	265	78	623	469
11	88	66	45	359	271	79	631	475
12	96	72	46	367	277	80	639	481
13	104	78	47	375	283	81	647	487
14	112	84	48	383	289	82	655	493
15	120	90	49	391	295	83	663	500
16	128	96	50	399	301	84	671	506
17	136	102	51	407	307	85	679	512
18	144	108	52	415	313	86	687	518
19	152	114	53	423	319	87	695	524
20	160	120	54	431	325	88	703	530
21	168	126	55	439	331	89	711	536
22	176	132	56	447	337	90	719	542
23	184	138	57	455	343	91	727	548
24	192	144	58	463	349	92	735	554
25	200	150	59	471	355	93	743	560
26	208	156	60	479	361	94	751	566
27	216	162	61	487	367	95	759	572
28	224	168	62	495	373	96	767	578
29	232	174	63	503	379	87	775	584
30	240	180	64	511	385	98	783	590
31	248	186	65	519	391	99	791	596
32	256	192	66	527	397	100	799	602
33	264	198	67	535	403	200	1597	1204
34	271	204	68	543	409	300	2396	1805

M.	38d.	52d.
1	8	6
2	16	12
3	24	18
4	31	25
5	39	31
6	47	37
7	55	43
8	63	49
9	71	55
10	79	62
11	87	68
12	95	74
13	102	80
14	110	86
15	118	92
16	126	99
17	134	105
18	142	111
19	150	117
20	158	123
21	166	129
22	173	136
23	181	142
24	189	148
25	197	154
26	205	160
27	213	166
28	221	172
29	229	179
30	236	185
31	244	191
32	252	197
33	260	203
34	268	209
35	276	216
36	284	222
37	292	228
38	299	234
39	307	240
40	315	246
41	323	252
42	341	259
43	339	265
44	347	271
45	355	277
46	362	283
47	370	289
48	378	296
49	386	302
50	394	308
51	402	314
52	410	320
53	418	326
54	426	332
55	433	339
56	441	345
57	449	351
58	457	357
59	465	363
60	473	369
61	481	376
62	489	382
63	496	388
64	504	494
65	512	400
66	520	406
67	528	412
68	536	419

Min.	38d.	52d.
69	544	425
70	552	431
71	559	437
72	567	443
73	575	450
74	583	456
75	591	462
76	599	468
77	607	474
78	615	480
79	622	486
80	630	493
81	638	499
82	646	505
83	654	511
84	662	517
85	670	523
86	678	530
87	686	536
88	693	542
89	701	548
90	709	554
91	717	560
92	725	566
93	733	573
94	741	579
95	749	585
96	756	591
97	764	597
88	772	603
99	780	610
100	788	616
200	1576	1231
300	2364	1847

34=
10
52

M.	39d.	51d	M.	39d.	51d	Min.	39 d.	51 d.
1	8	6	35	272	220	69	536	434
2	16	13	36	280	226	70	544	440
3	23	19	37	287	233	71	552	447
4	31	25	38	295	239	72	559	453
5	39	31	39	303	245	73	567	459
6	47	38	40	311	252	74	575	466
7	54	44	41	318	258	75	583	472
8	62	50	42	326	264	76	591	478
9	70	57	43	334	271	77	598	485
10	78	63	44	342	277	78	606	491
11	85	69	45	350	283	79	614	497
12	93	75	46	357	289	80	622	503
13	101	82	47	365	296	81	629	510
14	109	88	48	373	302	82	637	516
15	116	94	49	381	308	83	645	522
16	124	101	50	388	315	84	653	529
17	132	107	51	396	321	85	661	535
18	140	113	52	404	327	86	668	541
19	148	119	53	412	334	87	676	547
20	155	126	54	419	340	88	684	554
21	163	132	55	427	346	89	692	560
22	171	138	56	435	352	90	699	566
23	179	145	57	443	359	91	707	573
24	186	151	58	451	365	92	715	579
25	194	157	59	458	371	93	723	585
26	202	164	60	466	378	94	731	591
27	210	170	61	474	384	95	738	598
28	217	176	62	482	390	96	746	604
29	225	182	63	489	396	97	754	610
30	233	189	64	497	403	98	762	617
31	241	195	65	505	409	99	769	623
32	249	201	66	513	415	100	777	629
33	256	208	67	521	422	200	1554	1259
34	264	214	68	528	428	300	2331	1888

M.	40 d	50 d
1	8	6
2	15	13
3	23	19
4	31	26
5	38	32
6	46	38
7	54	45
8	61	51
9	69	58
10	77	64
11	84	71
12	92	77
13	100	83
14	107	90
15	115	96
16	123	103
17	130	109
18	138	116
19	146	122
20	153	129
21	161	135
12	169	141
23	176	148
24	184	154
25	192	161
26	199	167
27	207	173
28	214	180
29	222	186
30	230	193
31	237	199
32	245	206
33	253	212
34	260	219
35	268	225
36	276	231
37	283	238
38	291	244
39	299	251
40	306	257
41	314	263
42	322	270
43	329	276
44	337	283
45	345	289
46	352	296
47	360	302
48	368	309
49	375	315
50	383	321
51	391	328
52	398	334
53	406	341
54	414	347
55	421	353
56	429	360
57	437	366
58	444	373
59	452	379
60	460	386
61	467	392
62	475	399
63	483	405
64	490	411
65	498	418
66	506	424
67	513	431
68	521	437

Min.	40 d.	50 d.
69	529	443
70	536	450
71	544	456
72	552	463
73	559	469
74	567	476
75	574	482
76	582	485
77	590	495
78	597	501
79	605	508
80	613	514
81	620	521
82	628	527
83	636	533
84	643	540
85	651	546
86	659	553
87	666	559
88	674	566
89	682	572
90	689	579
91	697	585
92	705	591
93	712	598
94	720	604
95	727	611
96	735	617
97	743	623
98	751	630
99	758	636
100	765	643
200	1532	1286
300	2298	1928

M.	41 d	49 d	M.	41 d.	49 d	Min.	41 d.	49 d.
1	8	7	35	264	229	69	521	452
2	15	13	36	272	236	70	528	459
3	23	20	37	279	243	71	536	466
4	30	26	38	287	249	72	543	472
5	38	33	39	294	256	73	551	478
6	45	39	40	302	262	74	558	485
7	53	46	41	309	269	75	566	492
8	60	52	42	317	275	76	574	498
9	68	59	43	324	282	77	581	505
10	75	66	44	332	289	78	589	512
11	83	72	45	339	295	79	596	518
12	91	79	46	347	302	80	604	525
13	98	85	47	354	308	81	611	531
14	106	92	48	362	315	82	619	538
15	113	98	49	369	321	83	626	544
16	121	105	50	377	328	84	634	551
17	128	112	51	385	334	85	641	557
18	136	118	52	392	341	86	649	564
19	143	125	53	400	348	87	656	571
20	151	131	54	407	354	88	664	577
21	159	138	55	415	361	89	671	584
22	166	144	56	422	367	90	679	590
23	174	151	57	430	374	91	687	597
24	181	157	58	438	380	92	694	603
25	189	164	59	445	387	93	702	610
26	196	171	60	453	394	94	709	616
27	204	177	61	460	400	95	717	623
28	211	184	62	468	407	96	724	629
29	219	190	63	475	413	87	732	636
30	226	197	64	483	420	98	739	643
31	234	203	65	490	426	99	747	649
32	241	210	66	498	433	100	755	656
33	249	216	67	506	439	200	1509	1312
34	257	223	68	513	446	300	2264	1968

M.	42d.	48d.
1	7	7
2	15	13
3	22	20
4	30	27
5	37	33
6	44	40
7	52	47
8	59	53
9	67	60
10	74	67
11	82	73
12	89	80
13	97	87
14	104	93
15	111	100
16	119	107
17	126	113
18	134	120
19	141	127
20	149	134
21	156	140
22	163	147
23	171	154
24	178	160
25	186	167
26	193	174
27	201	180
28	208	187
29	215	194
30	223	201
31	230	207
32	238	214
33	245	221
34	253	227

M.	42d.	48d.
35	260	234
36	267	241
37	275	247
38	282	254
39	290	261
40	297	268
41	304	274
42	312	281
43	319	287
44	327	294
45	334	301
46	342	308
47	349	314
48	357	321
49	364	328
50	372	335
51	379	341
52	386	348
53	394	354
54	401	361
55	409	368
56	416	375
57	423	381
58	431	388
59	438	394
60	446	401
61	453	408
62	461	415
63	468	421
64	475	428
65	483	435
66	490	442
67	498	448
68	505	455

Min.	42d.	48 d.
69	513	462
70	520	468
71	527	475
72	535	482
73	542	488
74	550	495
75	557	502
76	564	509
77	572	515
78	579	522
79	587	529
80	594	535
81	602	542
82	609	549
83	617	555
84	624	562
85	632	569
86	639	575
87	647	582
88	654	589
89	661	595
90	669	602
91	676	609
92	684	615
93	691	622
94	699	629
95	706	635
96	713	642
97	721	649
98	728	655
99	736	662
100	743	669
200	1486	1338
300	2229	2007

M.	43 d	47 d	M.	43 d	47 d	Min.	43 d.	47 d.
1	7	7	35	256	239	69	505	470
2	15	14	36	263	245	70	512	477
3	22	20	37	270	252	71	519	484
4	29	27	38	278	259	72	526	491
5	36	34	39	285	266	73	534	498
6	44	41	40	292	273	74	541	505
7	51	48	41	300	280	75	548	511
8	58	54	42	307	286	76	556	518
9	65	61	43	314	293	77	563	525
10	73	68	44	322	300	78	570	532
11	80	75	45	329	307	79	578	539
12	88	82	46	336	314	80	585	546
13	95	89	47	344	320	81	592	552
14	102	95	48	351	327	82	600	559
15	110	102	49	358	334	83	607	566
16	117	109	50	366	341	84	614	573
17	124	116	51	373	348	85	622	580
18	132	123	52	380	355	86	629	587
19	139	130	53	388	361	87	636	593
20	146	136	54	395	268	88	643	600
21	153	143	55	402	375	89	651	607
22	161	150	56	409	382	90	658	614
23	168	157	57	417	389	91	665	621
24	175	164	58	424	395	92	673	627
25	183	170	59	431	402	93	680	634
26	190	177	60	439	409	94	687	641
27	197	184	61	446	416	95	695	648
28	205	191	62	453	423	96	702	655
29	212	198	63	461	430	97	709	661
30	219	205	64	468	436	98	717	668
31	227	211	65	475	443	99	724	675
32	234	218	66	483	450	100	731	682
33	241	225	67	490	457	200	1463	1364
34	248	232	68	497	464	300	2194	2046

M	44d	46d
1	7	7
2	14	14
3	22	21
4	29	28
5	36	35
6	43	42
7	50	49
8	58	56
9	65	62
10	72	69
11	79	76
12	86	83
13	93	90
14	101	97
15	108	104
16	115	111
17	122	118
18	129	125
19	137	132
20	144	139
21	151	146
22	158	153
23	165	160
24	173	167
25	180	174
26	187	181
27	194	188
28	201	195
29	209	201
30	216	208
31	223	215
32	230	222
33	237	229
34	245	236

M.	44d.	46d
35	252	243
36	259	250
37	266	257
38	273	264
39	280	271
40	288	278
41	295	285
42	302	292
43	309	299
44	316	306
45	324	313
46	331	320
47	338	327
48	345	334
49	352	340
50	360	347
51	367	354
52	374	361
53	381	368
54	388	375
55	396	382
56	403	389
57	410	396
58	417	403
59	424	410
60	432	417
61	439	424
62	446	431
63	453	438
64	460	445
65	468	452
66	475	458
67	482	465
68	489	472

Min.	44 d.	46 d.
69	496	479
70	503	486
71	511	493
72	518	500
73	525	507
74	532	514
75	539	521
76	547	528
77	554	535
78	561	542
79	568	549
80	575	556
81	583	563
82	590	570
83	597	577
84	604	584
85	611	590
86	619	597
87	626	604
88	633	611
89	640	618
90	647	625
91	655	632
92	662	639
93	669	646
94	676	653
95	683	660
96	690	667
97	698	674
98	705	681
99	712	688
100	719	695
200	1439	1389
300	2158	2084

M	45d	45d
1	7	7
2	14	14
3	21	21
4	28	28
5	35	35
6	42	42
7	49	49
8	56	56
9	64	64
10	71	71
11	78	78
12	85	85
13	92	92
14	99	99
15	106	106
16	113	113
17	120	120
18	127	127
19	134	134
20	141	141
21	148	148
22	155	155
23	163	163
24	170	170
25	177	177
26	184	184
27	191	191
28	198	198
29	205	205
30	212	212
31	219	219
32	226	226
33	233	233
34	240	240

M.	45d.	45d
35	247	247
36	254	254
37	261	261
38	268	268
39	275	275
40	283	283
41	290	290
42	297	297
43	304	304
44	311	311
45	318	318
46	325	325
47	332	332
48	339	339
49	346	346
50	353	353
51	360	360
52	367	367
53	375	375
54	382	382
55	389	389
56	396	396
57	403	403
58	410	410
59	417	417
60	424	424
61	431	431
62	438	438
63	445	445
64	452	452
65	459	459
46	466	456
67	474	474
68	481	481

Min.	45 d	45 d.
69	488	488
70	495	495
71	502	502
72	509	509
73	516	516
74	523	523
75	530	530
76	537	537
77	544	544
78	551	551
79	558	558
80	566	566
81	573	573
82	580	580
83	587	587
84	594	594
85	601	601
86	608	608
87	615	615
88	622	622
89	629	629
90	636	636
91	643	643
92	650	650
93	657	657
94	665	665
95	672	672
96	678	678
97	686	686
98	693	693
99	700	700
100	707	707
200	1114	1414
300	2121	2121

Now for the form of ſetting down a Reckoning, although he which is accuſtomed to keep it in this manner, may haply by uſe and practice diſcern how to order it in a better way then I can preſently preſcribe or think upon, becauſe he hath occaſion often to conſider it in every particular: yet in the mean time I conceive it will be fit to have a Book in *Folio*, that is, two Leaves to a ſheet of Paper, and to keep the left ſide of your Book void, that you may write therein all ſuch Occurrences as you ſhall think requiſite. As namely, the Winds, and the Points of the Compaſs, upon which your Ship lies, and what allowance you make for *Lee-ward* way when you Sail by a Wind, the number of Glaſſes or hours, and how many Knots or Miles in each hour, alſo the Latitudes which you find by Obſervation of the Meridian altitude of the Stars, and what elſe you ſhall think remarkable. But before all this, the title of the voyage in theſe or the like words,

The Journal of our Voyage intended by Gods aſſiſtance from S. I. *in the Latitude of* 32 deg. 25 min. *to the Coaſt of* England, *&c.*

The right hand Pages, or the right ſide of your Book throughout, may by Lines be divided into 12 Columns, as in the Example following doth appear. In the firſt Column may be expreſſed the Day, in the ſecond the Month; or at leaſt once in the top of the Page; likewiſe in the ſame ſecond Column, being large enough, may be ſet down the Latitudes which you find by the Meridian-altitudes of the Sun at ſuch times as you make obſervation. In the third Column the Courſe (the *Lee-ward* way, if there be any Leeing allowed.) In the *4th* the variation of the Needle. In the *5th* (having made allowance for the variation) ſet down the Angle of your Rumb with the Meridian. In the 6 Column ſet down the diſtance in Miles run upon that Rumb. In the 7, 8, 9, and 10 Columns the Northing or Southing, Eaſting or Weſting, thereto anſwering, as you ſhall find it by your Table. In the *11th* your Latitudes by dead reckoning. And laſtly, in the 12 Column you may at ſuch times as you think fitteſt, ſet down your *Longitude* from the place from which you firſt departed, or the difference of Longitude from place to place.

da.	Lat. by observation.	course	Variation.	Deg. fr. the merid	di. in miles	Nor.	Sou.	East	West	Lat. by dead R. de.	Longitude.
20	February	N E by E	8deg. west	n e 48d	miles 78	522		579		33.17	
21	Latitude 34 d. 25′	N E by E	8deg. west	n e 48d	100	669		743		34.24	
21	34 d. 25			Summe is		1191		1322		34.24	02.38
22		ene ½ poi.	8deg. west	n e 54d	100 56	588 329		809 453		35.56	
23	Latitude 37 d. 46′	ene ½ no.	8deg. west	n e 54d	100 78	588 458		809 631		37.40	
24	Latitude 39 d. 36′	ene ½ no.	8deg. west	n e 54d	100 84	588 494		809 679		39.28	
				Summe is		3045		4190			
		The correction by obser. is				801		1101		081	
24	39.36					3125		4300		39.36	11.36
25	February	ene	8deg. west	n e 59½	100 76	507 385		861 655		41.05	
26		ene	8deg. west	n e 59½	100 80	507 412		861 686		42.37	
27	Latitude 43 d. 55	ene	7½deg. west	n e 60d	100 84	500 420		866 728		44.09	
				Summe is		2731		4657			
				Correction				1401	2451	14	
27	L. 43. 55					2591		4412		43.55	21.28
28	February	ene ½ e	6deg. west	n e 67 d	100 51	391 199		921 469		44.54	
29		ene ½ e	5deg. west	n e 68 d	100 81	375 304		927 751		46.02	
1	March	ene ½ e	4deg. west	n e 69 d	100 66	358 237		934 616		47.02	
2	La. 48. 4.	ene ½ e	2deg. west	n e 71 d	100 78	326 254		946 737		48.00	
2	La. 48. 4.			Summe is		2444		6301		48.00	36.38

da	Lat. by observation.	cours.	Variation.	Dep. fr the Mer.	di. in miles	Nor.	Sou.	East	West	Lat by dead R.	Longitude.
3	March	e ne ½ e	0 de. west	ne 73 d	100 52	292 152		956 497		48.44	
4		e ne ½ e	2 de East	ne 75 d	100 68	259 176		906 657		49.28	
5	Latitude 49.58 d.	e ne ½ e	3 de. East	ne 76 d	98	237		951		49.52	
5	la. 49.58			Summe is		1116		14027		49.52	46.52
5	8 Hours	n bye e ½ e	4 de. East	ne 21 d	18	168		64		50.09	
6		south by e	4 de East	se 7 d.	34		337	41		49.35	
6	16 Hours	n by east	4 de. East	ne 15 d	36	348		93		50.10	
7		se by east	4 de. East	se 52 d	20		123	158		49.58	
8	Latitude 50 d. 4'	East	4 de. East	se 86 d	96		67	958		49.51	
	The current setting by estima.	East nort. east.		ne 67 ½	60	230		554		50.14	
				Summe is		219		1868			
				Correction			100			10'	
8	l. 50 d. 4					119		1868		50.04	51.43
9		east ½ po. n	6 de East	se 89 ½ d	70		60	700		49.58	
10		east ½ po. n	6 de East	se 89 ½ d	52		41	520		49.54	
10	March			Summe is		1101		1220		49.54	54.53
	Here the Lizard bears	N by E			13						

For an Example, we may frame a Reckoning between the two places before-mentioned, namely from *Summers Iſlands* to the *Lizard*, whoſe diſtance in the Rumb we have before ſuppoſed to be 3299 Miles, as ſome Charts make it, and conſequently their difference of Longitude 70 *deg.* I would not be underſtood as if I affirmed it to be ſo much, for I ſuppoſe it is leſs. I was there indeed about 20 years paſt, and Surveyed it, and than kept a Reckoning both outwards and homewards, but I have loſt thoſe Reckonings long ſince, and have forgotten what they were, and in this caſe it matters not; for whether the ſuppoſition be near the truth or not, it ſerves ſufficiently to exemplifie the Rule, that being the end for which it is uſed. But if their diſtance be 3299 ſuch Miles as contain only 1000 Paces in a Mile, the ſame being reckoned in ſuch Miles, as we have before mentioned, namely, in ſuch whereof 60 make a *degree* of a great Circle, which as we find contain 6120 Feet in a Mile, their diſtance will be little more than 2695 Miles, and conſequently, the difference of Longitude little more than 55 $\frac{1}{2}$ *degrees.*

Let us therefore ſuppoſe the difference of Longitude between thoſe two places to be 55 *degrees*, and their Latitudes to be the ſame as before, namely of the one 32 *deg.* 25 *min.* and of the other 50 *degrees.* And let the Courſes, Diſtances, and other Obſervations from *Summers Iſlands* to the *Lizard* to be ſuch as before is ſhewed.

The firſt entrance in this Journal, (which is the 20 Day of *February*) is thus to be underſtood; namely, that from the time of ſetting Sail (which we ſuppoſe to be the 19 of *February*) till the 20 Day at noon, the Ship lies away, and makes her way good upon the North-eaſt and by Eaſt point of the Compaſs, but the variation being 8 *degrees* to the Weſtwards (as in the fourth Column appears) the Rumb upon which ſhe hath run is from the North to the Eaſtwards only 48 *deg.* as is expreſſed in the 5 Column (it is indeed 48 $\frac{1}{4}$ *deg.* but the $\frac{1}{4}$ *deg.* we omit, as for the other circumſtances not to be regarded) upon this Rumb ſhe runs 78 Miles, as in the 6 Column appears, and anſwerable thereto I find in the Table before-going, the Northing to be 52 $\frac{2}{10}$ miles,

and

and the Easting 57 $\frac{2}{10}$, as here in the seventh and ninth Column is expressed by these numbers 522 and 579 (for the first Figure towards the right hand signifyeth the tenth part of a Mile, the rest Miles.) Hence then the Northing being 52 Miles, if that be added to the Latitude from which it is reckoned, namely, 32 *deg.* 25 *min.* in makes the Latitude here to be 33 *deg.* 17 *min.* as in the 11 Column appears. In like sort, the second entrance being the 21 of *February*, sheweth that from the 20 Day at Noon to the 21, she made her way good upon the North-east and by East Point of the Compass, but the Variation being 8 *degrees* Westerly, the Angle of the Rumb with the true Meridian was from the North to the Eastwards 48 *degrees*, and so Sailing 100 miles, the Northing is 69 $\frac{2}{10}$ miles, and the Easting 74 $\frac{1}{10}$ miles, so that the Latitude now is 34 *deg.* 24 *min.* and the like is to be understood of all the rest.

Touching the Longitude expressed in the last Column, although a reckoning may be kept and set down without it, yet it is of very good use; and how to convert the Easting or Westing (that is, the miles expressed in the East and West Columns of your Journal) into *degr.* and *min.* of Longitude; we will shew afterwards, as also how you may easily correct your Course, and give the true Course or Rumb, allowing the Variation.

But first to proceed with this Journal, observing the Meridian altitude of the Sun upon the 23 and 24 *February*, I find that my Latitude upon the 24, is 39 *deg.* 36 *min.* whereas by dead reckoning it is but 39 *deg.* 28 *min.* so the difference is 8 more Northerly: but being well assured of the Latitude found by Observation, I correct the dead reckoning thereby, which may be done by the Rule of Proportion, saying;

As the sum of the North Column	3125	*Co. ar.*	6.50515
To the Sum of the East Column,	4300		3.63347
So the foresaid increase Northerly	80		1.90309
To the increase Easterly	110		2.04171

That is, 11 miles: for the first place towards the right hand is only for the tenth parts of a mile.

The

The ſame may alſo ſufficiently be found without the Rule of Proportion, by the foregoing Table, only for looking there under the *Degree* upon which I have Sailed, namely, under 54 *deg.* for 8 miles or 80 tenths of a mile, though I find not the ſame exactly, yet I find one which is near it, namely, 82, and againſt it in the next collateral Column 113, which is 11 $\frac{3}{10}$ miles (being too much by $\frac{1}{10}$ of a mile, becauſe the other is too much by $\frac{2}{10}$) I add therefore in the North Column of the Journal 8 miles, and the Eaſt Column 11 miles; and ſo whereas by dead reckoning, the Northing was but 304 $\frac{2}{10}$ miles, and Eaſting 194 miles; now having corrected it by obſervation, the Northing is 312 $\frac{2}{10}$ miles, and Eaſting 430 miles.

In like ſort upon the 27th day, I ſhould by dead Reckoning be in the Latitude of 44 *degr.* 09 *min.* but by a clear and good obſervation I find my ſelf in the Latitude of 43 *deg.* 55 *min.* that is, not ſo much Northerly by 14 *min.* therefore to correct it, I put in the South Column 14 miles or 140 tenths, and ſeeing my courſe was between the North and the Eaſt, and that I find my ſelf to be leſs to the Northwards, that is, more to the Southwards than my reckoning; therefore in probability I am alſo leſs to the Eaſtwards, that is, more to the Weſtwards than my reckoning; but to find how much, I look in the foregoing Table for the *degree* upon which I have Sailed, being from the North part of the Meridian to the Eaſtwards 60 *deg.* and under 60 *deg.* I look for 14 miles, or 140 tenths, and againſt it in the Column adjoyning I find 243, which I ſet down in my Journal in the Weſt Column, and ſo ſubſtracting the firſt from the North Column, the other from the Eaſt, I find that whereas by dead reckoning I ſhould be to the Northwards 273 $\frac{2}{10}$ miles, and to the Eaſtwards 465 $\frac{2}{10}$. Now having corrected it by Obſervation, I find that from the 24th day till this time I have run more Northerly than I was by 259 $\frac{2}{10}$ miles, and more Eaſterly by 441 $\frac{2}{10}$ miles.

But if your Courſe be near the Eaſt or Weſt, it may ſuffice to correct it in Latitude only, as in the Example of the 8 of *March* appears; for in that caſe you cannot correct the Longitude, but from ſome further ground.

If

If there be any Current, you may note it as is done in that Example following the 8th of *March*.

Now if you would set down this Reckoning upon the plain or common *Sea Chart*; First, if you desire to express every days account, you may begin for the 20th of *Febr.* and make a prick in your Plot that may be from the place from which you set sail to the Northwards 52 $\frac{8}{10}$ miles, and to the Eastwards 57 $\frac{2}{10}$; and so will this Point be distant from the place of your setting sail 78 miles North-east, and almost a quarter of a Point Easterly: then for the 21th day you may make another Prick, which may be from the form to the Northwards 66 $\frac{2}{10}$ miles, and to the Eastwards 74 $\frac{1}{10}$ miles, and so you may proceed with the rest. And thus you shall have a Prick on the Plot for every day more exactly set down, than could be done after the ordinary way by Course and Distance, or Course and Latitude, especially because in lining the Plot, there are not, nor cannot conveniently be drawn any more than the 32 Points of the Compass, *viz.* not half Points, quarters, or single *Degrees*.

But if you desire not to set down every days reckoning (which is not necessary to be done) you may set down every of the sums, as they are corrected by observation after the self-same manner.

Or you may add together all those sums, and so the sum total of the North Column will be 1049 miles, and of the East Column 2345 miles, therefore in the Meridian of the place from which you depart, you may set down to the Northwards of that place 1049 miles, which will fall in the Latitude of 49 *deg.* 54 *min.* almost, and from thence in that Parallel set down directly to the Eastwards 2345 miles, and there make a Prick for the place where the Ship then is the tenth of *March*, and so is all this Reckoning set down at once.

If you keep Reckoning according to *Mercator*, it will be requisite sometimes to sum up your Reckonings past, namely, so often as you make any notable alteration in your Course; and so this Reckoning or any other may be set down almost as easily on *Mercator's Chart*; the difference is, that here you must often alter your *Scale*, because the *deg.* of Latitude on this *Chart* are not

equal,

equal, but grow greater and greater towards the Poles. Now then the diſtance of two places is to be meaſured by that part of the Meridian, which is intercepted between the Latitudes of thoſe two places, Or if both places lie in one and the ſame Latitude, their diſtance is meaſured by a *degree* or other leſs quantity, taken about that Latitude; namely, half above, and half beneath.

Wherefore if you would make a Prick or Traverſe-point in *Mercators Chart*, anſwering to your reckoning for the firſt day, namely, until the 20 of *February* at Noon; it appears by your Journal that Prick muſt be to the Northwards of the place from which you departed $52\frac{2}{10}$ miles, and to the Eaſtwards $57\frac{2}{10}$ miles.

Now inſtead of the North or South Columns, you may more conveniently uſe the laſt Column but one, ſhewing in what Latitude every account doth fall; and ſo it appears, that the Prick for the 20 of *February* muſt be in the Latitude of 33 *deg.* 17 *min.* Therefore in the Meridian of the *Summers-Iſlands* from which you departed, make a Prick in the Latitude of 33 *deg.* 17 *min.* and from that Prick ſet down to the Eaſtwards in the ſame Latitude $57\frac{2}{10}$ miles, and where it ends is the Traverſe-point anſwering to the 20 of *February*: the like may be done for the 21 Day, and ſo for all the reſt. This 58 miles may be taken in the Meridian from the Latitude of 32 *degr.* 22 *min.* to the Latitude of 33 *deg.* 20 *min.* or otherwiſe you may take the half of it, which is 29 miles about the middle between both Latitudes and double it.

But it is ſufficient to ſet down the ſums of every two or three days account, or ſo often as there is any notable Difference in your Courſe. Thus if you would make a Prick in the *Chart*, anſwering to the 21 of *February* being the firſt ſum; I ſee by the Journal, that it muſt be in the Latitude of 34 *deg.* 24 *min.* and to the Eaſtwards of the place from which I departed $132\frac{2}{10}$ miles. Therefore in the Meridian of the place from whence I departed, I make a Prick in the Latitude 34 *degr.* 24 *min.* and from that Prick I ſet in the ſame Latitude to the Eaſtwards $132\frac{2}{10}$ miles, and where it ends is the Traverſe-point anſwering to the 21 of *February*, being the firſt ſum. This 132 miles may be taken in the Meridian within, or a little without the two Latitudes, as before, namely, from 32 *deg.* 20 *min.* to 43 *deg.* 32 *min.* In

In like ſort, if you would make a Prick for the ſecond ſum, being the 24 of *February*, it there appears that it muſt be in the Latitude of 39 *deg.* 36 *min.* and to the Eaſtwards of the Traverſe-Point laſt before made 430 miles; therefore in the Meridian of that Traverſe-point I make a Prick in the Latitude of 39 *deg.* 36 *min.* and from that Prick I ſet to the Eaſtwards in the ſame Latitude 430 miles, and where that ends is the Traverſe-Point anſwering to the 24 Day, and the like is to be underſtood of all the reſt.

Now this 430 miles may be taken ſeveral ways; for firſt, If I take one *Degree* about the middle of that part of the Meridian, which is intercepted between the Latitudes of the two places (as from 36 *deg.* 30 *min.* to 37 *deg.* 30 *min.*) and that *degree* ſeven times taken, is 420 miles, then about the middle, namely, 37 *deg.* I take 10 *min.* more, and ſo have 430 miles.

In like manner you may take two *deg.* or 120 miles to meaſure it thereby, which may be taken from 36 *degrees* to 38 *deg.* and the reſidue about 37 *degrees*, as before, *&c.*

Or you may take the half of 430 miles; namely, 215 miles, which is 3 *deg.* 35 *min.* which muſt be taken as before, about the middle of that part of the Meridian which is intercepted between the two Latitudes, and that doubled is 430 miles to be ſet to the Eaſtwards, as before.

And thus may this or any other Reckoning be ſet down without knowledge of the Longitudes, but more aptly and exactly by ſome Longitudes known, for then ſhall you have in the two laſt Columns the ſubſtance and principal ſcope of your Reckoning; namely, the Latitudes and Longitudes of all places, as you Sail, which may more eaſily and exactly be expreſs'd upon this *Chart*, then the Eaſterly or Weſterly diſtances; Therefore how this alſo may be done, we will ſhew, but firſt ſomething touching the *Compaſs*, and the Variation thereof, which ought not to be neglected in a Reckoning.

CHAP. X.

Of the Variation of the Compaſs, and how to rectifie a Courſe by the Variation known.

AMongſt all the myſteries which God hath of late years diſcovered to the World for the furtherance of *Navigation*, there is none more neceſſary, nor yet more admirable than the property of the *Needle* touched with the Load-ſtone, whereby in the vaſt Ocean, where all Land-marks fail, yea even in the darkeſt nights and cloſeſt weather, when neither Sun nor Stars are to be ſeen, the Mariner (as it were by a Meſſenger ſent from Heaven) is taught which way to direct his Ship; yea, as it were accompanied with a guide towards his deſired Port.

For the Needle touched, beſides other ſtrange properties, hath this, to point out in all quarters of the World, the North and South parts of the Horizon, and ſo having a Card thereto fitted with Rumbs and degrees, it ſheweth all points of the Compaſs, and degrees of the Horizon.

Yet very ſeldom exactly of it ſelf, without ſome farther Art and Induſtry of him that uſeth it; for though in ſome places it ſwerves not, yet in moſt parts of the World the North and South-points of the Needle have ſome *Variation* from the true North and South points of the Horizon to the Eaſtwards or to the Weſtwards, which how to diſcover in kind and quantity, we have ſhewed heretofore.

It may be thought, (and ſome men, otherwiſe learned, before this property was fully diſcovered, have ſaid) that this ſhould be ſome blemiſh and imperfection in a ſtone ſo precious: but it is ſo far from being an imperfection, that it makes it ſo much the more precious. Yet (as I have ſaid) not without the induſtry of him that uſeth it. He that is negligent or unskillful to obſerve it, eſpecially in long Voyages and various Courſes, may be led into many dangers by it, becauſe he frames not his mind to the Rule, but the Rule to his Mind, imagining it to be what it is not: and

and hence I ſuppoſe ſprang that cuſtom of placing the *Needle* or *Wyars* a point or half point to the Eaſtwards of the North-point of the Card, thinking by this means to ſhun the labour of obſerving the Variation, which indeed they might, if the Variation were the ſame in all places, and at all times; but becauſe it is not, this doth often increaſe the Errour.

But he that diligently obſerves the Variation, finds (as I ſay) no prejudice in it, only it requires daily, or once in two or three days half an hours work; and this labour it doth abundantly recompenſe; for by this means he knows at the preſent how to direct his Courſe, and for the future, by thoſe notes which he keeps of the *Variations* and *Latitudes* by him obſerved, he knows (coming that way again) when he draws near to any of thoſe places where ſuch obſervations were made, and ſo falls the more certainly with any place intended.

There is further diſcovered of late a motion or alteration in the *Variation* of the *Needle*, and this is ſcarce yet certainly diſcovered. But comparing the Variations which were obſerved about fifty years paſt, with the preſent Variations; it appears they are leſſer Eaſterly, and more Weſterly by 6 or 7 degrees, than they were at that time. For whereas the Variation hath formerly been obſerved neer *London* to be 11 $\frac{1}{4}$ *degr.* to the Eaſtwards, it doth now ſcarce exceed 4 Degrees. And there is the like alteration (as I have heard by ſome Mariners (in other parts of the World; which we now leave to the further diſcovery of time and induſtry, and come to ſhew how to rectifie a Courſe by the Variation known.

The point of the Compaſſe upon which you ſail, and the Variation of the Needle known, to find the Rumb or Degree upon which the Ship hath made her way.

IT is beſt that the *Needle* or *Wyars* be placed directly under the *Flower-de luce*, or *North* and *South* points of the *Card*, and ſo in the Rules following we preſuppoſe them to be. Now then it is to be underſtood, that the *Needle* having Variation

(as for the moſt part it hath) the Ship doth not make her way upon that Rumb or Point of the Compaſs, which ſhe ſeems to ſail upon, but either more to the right hand or to the left, according as the Variation is towards the right hand, or towards the left, and that ſo much towards the one ſide, or towards the other as that Variation is: We ſpeak not here of *Lee-ward* way, but of the Variation only. Therefore for the ſolution of this *Problem*, you muſt know how much the Variation is, and which way; and how this may be done, we have briefly ſhewed upon the 12 Caſe of *right angled Spherical Triangles*, and the 11 of *oblique*, which known, you may find the Angle of the Rumb or line of your ſhips way with the *Meridian*, being the thing in this *Problem* required.

A Table of the Angles of every Point and half Point of the Compaſs with the Meridian.

			D. M.		
	North.	*South.*	00 00	*North.*	*South.*
½			05 37		
1	*N* by *E*	*S* by *W*	11 15	*N* by *W*	*S* by *E*
1½			16 52		
2	*N N E*	*S S W*	22 30	*N N W*	*S S E*
2½			28 07		
3	*N E* by *N*	*S W* by *S*	33 45	*N W* by *N*	*S E* by *S*
3½			39 22		
4	*N E*	*S W*	45 00	*N W*	*S E*
4½			50 37		
5	*N E* by *E*	*S W* by *W*	56 15	*N W* by *W*	*S E* by *E*
5½			61 52		
6	*E N E*	*W S W.*	67 30	*W N W*	*E S E*
6½			73 07		
7	*E* by *N*	*W* by *S*	78 45	*W* by *N*	*E* by *S*
7½			84 22		
8	*East.*	*West.*	90 00	*West.*	*East.*
	Add Eaſt Variation, Subſtract Weſt.			Add Weſt Variation, Subſtract Eaſt.	

For

For the effecting whereof, we will ſet down two ways; the one by the Pen alone, the other inſtrumentally. If you do it by the Pen alone, although it be not hard to find what Angle every Point or half Point makes with the Meridian; yet for your further eaſe herein, I have expreſſed the ſame in the Table before-going; the quarters of Points I have omitted, becauſe the Steerage upon a quarter of a Point is very uncertain (the Points being undivided as uſually they are) for a man by his eye is able to gueſs very nearly which is the middle between two Points, but he cannot gueſs ſo nearly which is the fourth part. Yet if you deſire any quarter, you may add to the next before-going almoſt 3 *Degrees*; namely, 2 *Deg.* 49 *min.*

Now then by the Magnetical Rumb or Point of the Compaſs and Variation given, to find the true Rumb, you are to obſerve theſe two Rules following.

1. *If the Rumb and the Variation be both the ſame way from the Meridian* (*namely, both to the right haud, or both to the left*) *add them together, and that ſum is the true Rumb from that part of the Meridian.*

Yet if that ſum exceed 90 degrees, *Subſtract it from* 180 degrees, *the remainder is the Rumb from the oppoſite part of the Meridian.*

2. *If the one be towards the right hand, the other towards the left, Subſtract the Variation from the Rumb, and the Remainder is the true Rumb.*

Yet if the Rumb be the ſmaller number, Subſtract it from the Variation, and the Remainder is the true Rumb the other way.

Theſe Rules we ſhall endevour to illuſtrate by examples following:

But firſt for diſtinction ſake, we ſay the Rumbs or *Degrees* from the North towards the Eaſt, are towards the right hand, and ſo from the South towards the Weſt; but from the North to the Weſtwards, on the left hand, and ſo from the South Eaſtwards: For a mans face being towards the North, the Eaſt is on his right hand, and the Weſt on his left, *&c.*

In like ſort for the *variation of the Compaſs*, if it have Eaſterly *variation*, that is, if the *Needle* and *Flower-de-luce* of the *Card* ſtand

ſtand to the Eaſtwards of the North, we ſay that *Variation* is towards the right hand, for not only the North-point, but all the other points of the *Compaſs* direct a Courſe more towards the right hand than they would do, if there were no *Variation*. And ſo if it have Weſterly *Variation*, that is, if the *Needle* and *Flower-de-luce* ſtand to the Weſtwards of the true North-point of the *Horizon*, we ſay that *Variation* is towards the left hand; foraſmuch as not only the North-point, but all the other points of the Compaſs ſtand more towards the left hand than they would do, if there were no *Variation*. This being premiſed, we come to give *Examples* of the two Rules before-going.

1. Let the Magnetical Rumb or Point of the Compaſs be North-eaſt, and the *Variation* 10 degrees to the Eaſtwards; I demand the true *Rumb*?

Here the *Rumb* and *Variation* are both one way; that is, both towards the right hand; therefore,

To the Magnetical Rumb being N. Eaſterly	45 *deg.* 0 *min.*
Add the Variation Eaſterly	10 *deg.* 0 *min.*
The ſum is the true Rumb N. Eaſterly	55 *deg.* 0 *min.*

2. Admit a Ship ſail upon the North-point of the Compaſs, and that the Variation be 10 deg. to the Eaſtwards, how doth ſhe make her way?

The Magnetical Rumb is North, that is,	00 *deg.* 0 *min.*
To which adding the Eaſterly Variation	10 *deg.* 0 *min.*
The ſum is the Angle from the North-part of the Meridian to the Eaſtwards	10 *deg.* 0 *min.*

Which is almoſt *N.* by *E.* and ſo hath the Ship made her way.

3. Let the point of the Compaſs be Eaſt ½ point Northerly, that is, from the North to the Eaſtwards 7 ½ points, which is 84 deg. 22 min. and the Variation as before 10 deg. to the Eaſtwards, I demand the true Rumb?

To the Magnetical Rumb being North-eaſt,	84 *deg.* 22 *min.*
Add the Eaſterly Variation	10 *deg.* 00 *min.*
The ſum is the Angle from the North	94 *deg.* 22 *min.*
Which ſubſtracted from	180 *deg.* 00 *min.*
There reſts the true Rumb South-eaſterly	85 *deg.* 38 *min.*

4 *Ex-*

4 *Example.* Let the course by the Compass be West and by South, that is 7 points from the South to the Westwards, or 78 *deg.* 45 *min.* and let the Variation be as before 10 *deg.* to the Eastwards, what is the true Rumb?

To the Magnetical Rumb *South Westerly*	78 *deg.* 45 *min.*
Add the *Easterly Variation*	10 *deg.* 00 *min.*
The sum is the true Rumb *South Westerly*	88 *deg.* 45 *min.*

You may conceive that the *Rumb* and *Variation* are here both one way; namely, both from the *Meridian* towards the right hand. For the Variation of the North-point is from the *North* towards the *East*, and consequently of the South-point from the *South* towards the *West*, both towards the right hand of the *Meridian*, as the *Rumb* is.

5 *Example.* Let the Course by the *Compass* be *West*, that is, from the *South* to the *Westwards* 8 points or 90 degrees, and let the Variation be as before 10 *deg.* to the *Eastwards*, I would know the true Course or *Rumb?*

To the Magnetical Rumb South-west	90 *deg.* 00 *min.*
Add the Variation *Easterly*	10 *deg.* 00 *min.*
The sum is the Angle with the *South* part of the *Meridian*	100 *deg.* 00 *min.*
Which substracted from	180 *deg.* 00 *min.*
There rests the true Rumb *N. West*	80 *deg.* 00 *min.*

Let the Course by the *Compass* be *West*, that is from the *North* to the *Westwards* 8 points or 90 degrees, and let the *Variation* be 10 *deg.* to the *Westwards*; I demand the true *Rumb?*

To the Magnetical Rumb *N. West*	90 *deg.* 00 *min.*
Add the Variation *Westerly*	10 *deg.* 00 *min.*
The sum is	100 *deg.* 00 *min.*
Which substracted from	180 *deg.* 00 *min.*
There remains the true Rumb *S. West*	80 *deg.* 00 *min.*

Object. The Magnetical Rumb being here West 90 *deg.* why should it not as well be counted from the *South* as from the *North?*

Answ. It may be counted from either; for as it is counted here from the North to the Westwards, it falls under the first *Rule*, because

becauſe the Variation is the ſame way: But if it be reckoned from the South to the Weſtwards, it falls under the ſecond Rule, whereof we now come to give ſome Examples, ſuppoſing theſe already given ſufficient to illuſtrate the firſt Rule.

7 *Example.* Let the Point of the Compaſs be N N W, and the Variation 10 *deg.* Eaſterly, I demand the true Rumb:

From the magnetical Rumb N W	22 *deg.* 30 *min.*
Subſtract the Eaſterly Variation	10 *deg.* 00 *min.*
The Remainder is the true Rumb N W	12 *deg.* 30 *min.*

8 *Example.* Let the Point of the Compaſs be North, and the Variation Eaſterly 10 *deg.* what is the true Rumb?

From the Eaſterly Variation	10 *deg.* 00 *min.*
Subſtract the magnetical Rumb N W	00 *deg.* 00 *min.*
The Remainder is the true Rumb, the other way, namely, N E	10 *deg.* 00 *min.*

Object. The magnetical Rumb may as well be named North-eaſterly 0 *deg.* 0 *min.*

Anſ. It may, but then it is ſubject to the firſt Rule, as in the ſecond *Example.*

9 *Example.* Let the Courſe of the Compaſs be Weſt, that is, from the North to the Weſtwards 8 Points or 90 *degrees*, and let the Variation be as before 10 *Degrees* to the Eaſtwards, what is the true Rumb?

From the magnetical Rumb N W	90 *deg.* 00 *min.*
Subſtract the Eaſterly Variation	10 *deg.* 00 *min.*
There reſts the true Rumb N W	80 *deg.* 00 *min.*

Here the magnetical Rumb might as well have been South-weſterly 90 *degr.* and ſo it had fallen under the firſt Rule, as in the fifth *Example.*

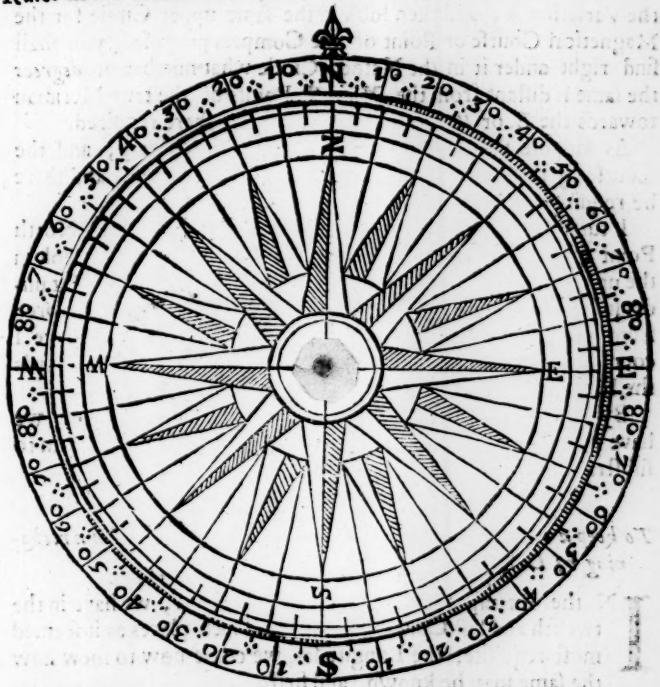
10 *Example.* Let the Courſe by the Compaſs be Weſt, that is, from the South to the Weſtwards 8 Points or 90 *Degrees*, and let the Variation be 10 *Deg.* to the Weſtwards, I demand the true Rumb?

From the magnetical Rumb S W	90 *deg.* 00 *min.*
Subſtract the Weſterly Variation	10 *deg.* 00 *min.*
The Remainder is the true Rumb S W	80 *deg.* 00 *min.*

If

If the Rumb here had been reckoned from the North, as in the ſixth Example, it had fallen under the firſt Rule.

And this may ſuffice for the Illuſtration of the two former Rules in the ſolution of this Problem.



The ſame may alſo more eaſily be reſolved, by ſuch an Inſtrument as is here deſcribed, conſiſting of two Circles, the one being the nethermoſt divided into four Quadrants, and every of thoſe into 90 *deg.* numbred from the North and South Points, towards the Eaſt and Weſt.

The other being the uppermoſt and moveable about the *Centre*, divided as the Card of the Compaſs into XXXII Points, and thoſe again ſub-divided into halves and quarters.

By this you may readily find the true Rumb for any Course and Variation given.

For if you turn the North Point of the upper Circle, from the North Point of the lower, so many *deg.* and the same way that the Variation is, and then look in the same upper Circle for the Magnetical Course or Point of the Compass proposed, you shall find right under it in the Nether Circle what number of *degrees* the same is distant from the *N.* or *S.* Points of the true Meridian towards the *E.* or *W.* which is the true Rumb here required.

As suppose the Variation to be 10 *deg.* Easterly, and the Course by the Compass East half a Point Northerly, and there be required the true Rumb.

I turn the North Point of the upper Circle from the North Point of the lower 10 *deg.* to the Eastwards, and then I look in the upper Circle, for East half a Point Northerly, and right under it in the Nether Circle I find 85 *d.* and about one half, numbred from the South Part of the Meridian towards the East, therefore I conclude that the true Rumb [illegible]ed is from the South towards the East, 85 ½ *deg.* and somethi[illegible]re.

By this Instrument also (if you use the Pen only, as before we have shewed) you shall readily see when to add, and when to substract.

CHAP. XI.

To keep a reckoning of your Longitude, and so to set down a reckoning by Longitude and Latitude only.

IN the Example before given of a Journal, we have in the twelfth and last Column expressed in such places as it seemed most requisite, the Longitudes, we come now to shew how the same may be known, and first,

By the Rumb and Latitudes given to find the difference of longitude.

As Radius is in proportion, to the Tangent of the Rumb;
So is the difference of Latitude in Meridional parts,
To the difference of Longitude in Minutes.

As let the Rumb be North-easterly 48 *deg.* and suppose a Ship to run upon this Rumb, from the Latitude of 32 *deg.* 25 *min.* into

into the Latitude of 34 *deg.* 24 *min.* there is required the difference of Longitude. Here,

The Meridional parts answering to 34 *deg.* 24 *min.*			2200
The Meridional parts for	32	25	2058
The difference of Latitude in such parts is			142

Say then, as *Radius* is in proportion

To the Tangent of the *Rumb*, 48 *deg.* 0 *min.*		10.0456
So the difference of Latitude in Merid. parts	142	2.1523
To the difference of Longitude in Minutes	158	2.1979

These Minutes converted into *deg.* are 2 *deg.* 38 *min.* which is the difference of Longitude required, as the same is expressed in the Journal against the 21 of *February*.

And thus sailing upon one and the same Rumb, you may find the difference of Longitude, and so often as you alter your Rumb, so often working by the same Rule, you shall have all the differences from place to place, which added together, make the whole difference of Longitude.

But you may also find the difference of Longitude near enough at one operation for many several Rumbs and Distances, provided that those Rumbs differ not much one from another. As in the former Journal from the 27 of February, till the 2 of *March*, I sail by several Rumbs and Distances from the Latitude of 43 *deg.* 55 *min.* into the Latitude of 48 *deg.* if you would find the difference of Longitude hereto answerable at one operation, it may be done by this Rule:

As the difference of Longitude in Miles,
Is to the departure from the Meridian in Miles,
So is the difference of Latitude in Meridional parts,
To the difference of Longitude in Minutes.

As in that Example the difference of Latitude for all those Courses, as in the North Column appears, is 2444.

The departure from the Meridian, as there in the East Column appears, is 6301.

The Merid. parts for the Latitude of 43 *deg.* 55 *m.* are	2939
The Merid. parts for the Latitude of 58 *deg.* 0 *m.* are	3292
Difference of Latitude in Meridional parts, is	353

Say then, As the difference of Latitude	2444	*co. ar.*	6.6119
To the departure from the Meridian	6301		3.7994
So the difference of Latit. in Merid. parts	353		2.5478
To the difference of Longitude in *min.*	910		2.9591

Which reduced into *degrees*, is 15 *deg.* 10 *min.* And added to the former Longitude 21 *deg.* 28 *min.* gives the present Longitude 36 *deg.* 38 *m* for the 2 of *March.*

The like may be done for the account from the 2 of *March*, to the 5 of the same, *&c.*

But if your courses and Distances run, be all near to one and the same Parallel or Latitude (as in this Journal they are from the 5 of *March* to the 8, and from the 8 to the 10,) then it is sufficient to find what Longitude in that Parallel is answerable to the miles of Easting or Westing, or departure from the Meridian by this Rule,

As the Sine Complement of the Latitude of that Parallel,
Is in proportion to *Radius*;
So is the Number of Miles in that Parallel,
To the difference of Longitude in Minutes.

As from the 5 of *March*, to the 8, the Latitude was near 50 *deg.* the Easterly distance 186 $\frac{8}{10}$ miles: therefore for the difference of Longitude, say:

As Sine Complement the Latitude, *s. c.* 50 *deg.* 0 *min.*			1919
To *Radius*,			
So is the departure from the Meridian	186	8	2.2714
To the difference of Longitude	290	6	3.4633

Thus it appears, the difference of Longitude is almost 291 *min.* which is 4 *deg.* 51 *min.* and this added to the Longitude upon the 5 of *March*, namely, to 46 *deg.* 52 *min.* the sum is 51 *deg.* 43 *min.* the Longitude upon the 8 of *March*: the like might be done for the 10 of *March.*

And though this last rule be then fittest to be used, when your Course is near East and West, or your difference of Latitude little, yet it may also be used at other times instead of the two former, without any great Errour, if you take the middle *degree* of Latitude, or somewhat more, as in the former Example.

The Latitude upon the 27 of *February* is 43 *deg.* 55 *min.*
The Latitude upon the 2 of *March* is 48 *deg.* 00 *min.*
The middle Latitude or somewhat more is 46 *deg.* 10 *min.*
Say then, as sine Comp. the Latitude *s. c.* 46 *deg.* 10 *m.* 1595
To *Radius*,
So the Easting or departure from the Merid. 630 1 2.7994
to the difference of Longitude, 909 7 3.9589

Which is almost 910 *min* or 15 *deg.* 10 *min.* as before.

And thus you may in the 12 and last Column of your Journal set down your Longitude so often as you think is requisite; and so in the two last Columns you shall have the substance and principal scope of your reckoning, namely, your Latitudes and Longitudes, which whensoever you desire to set down in *Mercator's Chart*, or in the *Polar Chart*, or in any other, graduated with *Degrees* of Longitude and Latitude, you may readily do it.

As if you would set down the sum of the foresaid Journal from the 19 of *February* to the 10 of *March*, I find against the 10 of *March* the Latitude to be 49 *deg.* 54 *min* and the difference of Longitude 54 *deg.* 53 *min.* Therefore in the Latitude of 49 *deg.* 54 *min.* I draw an occult Parallel, and reckoning from *Summers-Islands* towards the East 54 *deg.* 53 *min.* I draw by that Longitude an occult Meridian, the Intersection of this Meridian with the foresaid Parallel, is the Traverse-point, or the point representing the place of the Ship, and the like is to be understood of any other.

This form of keeping and expressing a Reckoning, is (as I conceive) most apt and agreeable (of all others that I have seen or thought upon) to all sorts of *Charts* or Maps, and to the *Globe* it self; and to all the kinds or ways of Sailing, that are or may be used. We will here add some other Propositions which may sometimes be of good and necessary use in it.

The Rumb and Difference of Latitude given, to find by the Table, the Distance in the Rumb, and the Departure from the Meridian thereto answerable, &c.

HOw to find the Northing or Southing, that is, the Distance in Latitude; as also the Easting or Westing, that is, the Distance

ſtance in Longitude, or departure from the Meridian of any Rumb, for any diſtance run upon it, we have before ſhewed, the like operation is in theſe Propoſitions following: namely,

2. *The Rumb and Diſtance in Latitude given: to find the Diſtance in the Rumb, and the Eaſting or Weſting.*

3. *The Diſtance and Difference in Latitude given: to find the Departure from the Meridian and the Rumb.*

4. *The Difference in Latitude, and Departure from the Meridian given: to find the Courſe and Diſtance,*

5. *The Courſe and Departure from the Meridian given: to find the difference of Latitude and Diſtance.*

6. *The Diſtance and Departure from the Meridian given: to find the Courſe and Difference of Latitude.*

So that with the firſt before-handled, here are ſix Propoſitions, and in every one of them two things required; and ſo they become 12. We will not ſtand to give examples of them all, but only of thoſe which are moſt uſeful, the reſt may by them be conceived.

And firſt, to find the Eaſting or Weſting of any Rumb for any difference of Latitude,

Admit a Ship run North-eaſterly 60 *deg.* (that is *N E* by *E*, and almoſt half a point Eaſterly) till ſhe have altered the Latitude 42 *min.* how much is ſhe departed from the Meridian?

I run down the Column under 60 *deg.* till I find 42 Miles, or 420 tenths, and againſt it in the adjacent Column I find 728 tenths, that is almoſt 73 Miles, which is the departure from the Meridian to the Eaſtwards.

If you would alſo have the diſtance upon the Rumb, it is right againſt theſe numbers in the Column of Diſtances, being in this Example 84 Miles.

2 *Example.* But admit ſhe run North-eaſterly 60 *deg.* till ſhe alter her Latitude 1 *deg.* 32 *min.* what is the Eaſterly diſtance?

This 1 *deg.* 32 *min.* is 92 Miles, or 920 tenths, for which if I look in the Col. under 60 *d.* I find no number ſo great, but the greateſt number there is 500, which ſubſtracted from 920, there remains 420, therefore in that Column under 60 *deg.*

100	500	866	
84	420	728	
184	920	1594.	

I

I look for these two numbers, namely, 500, and 420, and against the first in the adjacent Column I find 866, and against the second 728, which I set against them as above appeareth, and so adding them, I find for this difference of Latitude, the departure from the Meridian to be 159 $\frac{4}{10}$ Miles.

If further you desire the distance run upon this Rumb, you have it in the Column of Distances, right against the same numbers, as in the Example above appeareth, where being added, it amounts to 184 Miles.

The Distance and Difference in Latitude given: to find the Rumb and departure from the Meridian

ADmit a Ship run upon some Rumb between the North and the East 84 Miles, and then have altered her Latitude 42 *min.* the Question is, upon what Rumb hath she run, and how many Miles is she to the Eastwards in Longitude?

I run cross the Table towards the right hand, looking in every first Column of Distances for 84, till I find against it in one of the adjacent Columns 420, at the top of which Column over 420, there is 60 *Deg.* shewing the Rumb to be North-easterly 60 *D.* also against 420 in the adjacent Column I find 728, which sheweth the distance to the Eastwards to be almost 73 Miles.

2 *Example.* But if the distance run be 184 Miles, and the difference of Latitude 1 *deg.* 32 *min.* and there be required the Rumb and Distance to the Eastwards.

Because the Column of Distance extends but to 100 Miles, and the distance here given is 184 Miles, you may take the half thereof, which is 92 Miles, and likewise the half of 1 *deg.* 32 *min.* which is 46 Miles, or 460 tenths, and then look, as before, where you find 460 against 92, for there in the top of the Column you shall find the Rumb, which in this example is 60 *deg.* shewing that the Rumb is from the N. easterly 60 *deg.* and in the adjacent Column against 92 and 460, you shall find 797, which doubled (because it is for the half) is 1594, shewing that the departure from the Meridian to the Eastwards is 159 $\frac{4}{10}$ Miles. These and the rest may also be performed by the *Doctrine of plain Triangles*, as we have formerly shewed.

CHAP.

CHAP. XII.

Certain Problems touching Currents.

ALthough the time be already expired which I assigned for this Work, and mine own more urgent occasions call me away, yet seeing it is necessary in *Navigation* to take notice of Currents, and to make a competent allowance for them: I will briefly set down certain *Problems*, such as I have sometimes thought upon, whereby a man may the better conceive and judge of that allowance, the rather for that I know not any that have handled it.

First then, it is to be conceived, that a Ship or other Vessel Sailing or Rowing where there is a Current, hath a compound motion arising of two different Principles; namely, of the Current and Ships way, so that here are three motions to be considered, namely, two simple, and the third compounded of them. The first simple motion is that of the Current, whereby it moveth, and is apt to move other things that are in it the same way. The second, of the Ship or Boat, as it moveth by Wind or Oars, or is apt to be moved, if there were no Current. The third, compounded of them, is the Line of the Ships true motion. The first, we call the way or motion of the Current: The second, the way, or simple motion of the Ship: The third, her compound or true way. The two simple motions being either of them according to right Lines and uniform (as in the *Problems* following we suppose them to be.) The third also, which is composed of them, is a right Line; for whether the Ship sail directly opposite against the Current, or directly with it the same way, or whether the one cross the other at right Angles or at oblique; yet still either motion being direct and uniform, they both together beget a right lined uniform motion, because the one retaineth to the other the one and the same proportion in every Point: And according to these grounds we proceed in the *Prob.* following, to determine the proportions of every of these motions, and the Angles which they make one with another.

1. *Ad-*

1. *Admit a Current run East 3 Miles an hour, and that a Ship under Sail run West directly against it 6 Miles an hour in her simple motion, what is her true or compound motion?*

From the Ships simple motion	6 miles
Substract the Current	3 miles
The Remainder is the Ships true motion	3 miles

So the Ships true way is to the Westwards 3 miles an hour.

2. *Admit a Current run West 6 Miles an hour, and that a Ship under Sail run directly against it 5 Miles an hour by the Log: what is the Ships compound motion, and which way?*

From the Current being the greater	6 miles
Substract the Ships simple motion	5 miles
There remains the Ships true motion	1 mile

Which 1 mile shews, that the Ship by her compound motion falls a stern, that is, moves to the Westwards 1 mile an hour.

In the experimental Practice of the two former *Problems*, it may seem, that a Ship or Boat so ordered, hath also a motion to the right hand or to the left, but this comes to pass, because it is hard, and in a manner impossible, to stem a Tide or Stream so exactly, but that the Ship will swerve (or yaw as they say) either to the one side or to the other.

3. *Admit a Current run East 3 Miles an hour, and that the Ship also run East 3 Miles an hour by the Log: what is the Ships true motion?*

To the Ships simple motion	3 miles
Add the Current	3 miles
The Sum is the Ships true motion	6 miles

So the Ships compound or true way is 6 miles an hour.

4. *Admit a Current run East 2 Miles an hour, and the Ship South 6 Miles an hour: what is the Ships true motion, and which way?*

In handling of any Art, to avoid circumlocution, there are used Terms or Words of Art, serving to express briefly the things handled. And forasmuch as this Subject hath not been formerly handled, nor the Principles or Grounds thereof laid (so far as I know) we will add a few such terms as may seem most necessary, expressing here what we mean by them.

Let the Line *A B* run from *A* to the Southwards, and *B D* from *B* to the Eastwards, and let *A B* be in proportion to *B D*, as 6 to 2, or 3 to 1.

Then doth *A B* represent the line of the ships simple motion, *B D* the motion of the Current, and *A D* the compound motion of the Ship.

And *D A B* is the Angle contained between the line of the Ships simple motion, and the line of her compound or true motion, which for brevity sake we will henceforth call the *Angle of Deflection*. Also *A D B* is the angle contained between the line of the Ships compound motion, and the set or drift of the Current, which we call the *Angle of Reflection*.

Lastly, *A B D* is the angle contained between the line of the Ships simple motion, and the set of the Current, which we will call the *Angle of Incidence*.

Then for the Rumb, the proportion is thus.

As the simple motion	*A B* 6 miles	*co. ar.*	9.2219
Is to the Current	*B D* 2 miles		0.3011
So is *Radius*			
To the Tangent of Deflection	*t D A B* 18 *deg.* 26 *min.*		9.5230

So the Rumb upon which the Ship makes her way good is South 18 *deg.* 26 *min.* Easterly, that is, SSE 4 *deg.* 4 *min.* Southerly.

2. *For the Ships true way, or compound motion.*

As the Sine of the Deflection	*s D A B* 18 *deg.* 26 *min.*		0.5000
To the Current	*D B* 2 miles		0.3011
So *Radius*			
To the true motion	*A D* 6 $\frac{12}{100}$		0.8011

So the Ships compound motion is 6 $\frac{12}{100}$ miles hourly, that is, 6 $\frac{1}{3}$ miles almost.

5. *A Ship sails West 5 days together by the* Log. *725 miles, but there is a Current, all this while setting to the Southwards 1 $\frac{1}{2}$ miles an hour: I demand how she hath sailed and how far?*

The Current setting 1 $\frac{1}{2}$ miles an hour, sets in 5 days 180 miles: Therefore, As

As the ſimple motion	*AB* 725 miles	7.1397
Is to the Current	*DB* 180 miles	2.2553
So is *Radius*		
To the Tangent of Deflection	*t DAB* 13 *d.* 57 *m.*	9.3950

For the Diſtance.

As ſine compl. the Deflection	*sc DAB* 13 *d.* 57 *m.*	0.0130
Is to the ſimple motion	*AB* 725 m.	2.8603
So is *Radius*		
To the compound motion	*AD* 747 miles.	2.8733

So the Ships true way is Weſt Southerly 13 *deg.* 57 *min.* or Southweſterly 76 *deg.* 3 *min.* 747 miles.

6. *A Ship ſails Weſt* 5 *days together by the* Log. 725 *miles, in a Current ſetting to the Southwards, and then finds that he hath altered his Latitude* 3 degrees; *I demand the motion of the Current, the Rumb and true way of the Ship?*

This Queſtion differeth little from the former, for ſeeing the difference of Latitudes is 3 *deg.* the motion of the Current is 180 miles: ſo there is given the Ships ſimple motion, and the motion of the Current, as before, *&c.*

7. *A Ship in* 6 *hours ſails from a certain* Cape *or Head-land South* 30 *miles by the* Log, *in a Current ſetting Eaſterly, and then obſerving the ſame* Cape, *he finds that it bears* NNW; *I demand how faſt that Current ſets, and how far he hath ſailed?*

As let a Ship ſail from *A* towards *B* South 30 miles, but by means of the Current, ſhe is driven more Eaſterly, namely to *D*, from whence ſetting the Cape *A*, it is found to bare *NNW.* And ſeeing the Current ſets from *B* towards *D* Eaſterly; therefore the angle of Reflection *BDA* is 6 Points, that is, 67 *deg.* 30 *min.* Here then is demanded the diſtance *AD*, and the drift of the Current in that time *BD.*

As the ſine of the angle of Reflection	*s BDA* 67 *d* 30 *m.*	.0344
To the ſimple motion of the Ship	*AB* 30 miles	1.4771
So the ſine of the angle of Deflection	*sDAB* 22 *d.* 30 *m.*	9.5736
To the motion of the Current	*BD* 12 $\frac{16}{100}$	1.0851

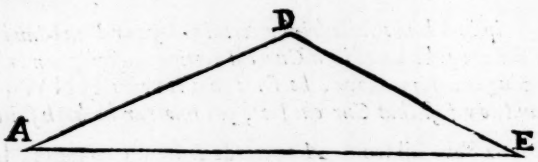
And further,

As the sine of the Angle of Reflection *s B D A* 67 *d.* 30 *m.*	0344	
To the distance run by the Log *A B* 30 miles,		1.4771
So is *Radius*		
To the compound motion of the Ship *A D* 32 $\frac{42}{100}$		1.5115

And thus we fiud that Current to set 12 $\frac{16}{100}$; that is, near 12 $\frac{1}{6}$ miles in six hours, and the distance run to be 32 $\frac{1}{2}$ miles almost.

That the thing may be better conceived, we will use two or three Examples more familiar and obvious to every mans experience; yet grounded upon the same Principles and Reasons.

8. *Admit that* Tulis-stairs *bear from* Billinsgate-stairs *South-west Southerly, namely, South-westerly* 40 degrees, *and be distant* 80 *Poles; and suppose the Tide of ebb to run there East-ward* 2 $\frac{1}{2}$ *Miles an hour, and that a pair of Oars, rowing* 4 $\frac{1}{2}$ *Miles an hour, would go straight over from the first to the second: How shall they row over, namely, upon what* degree *or Point of the Compass, and how far shall they row to get thither, and in what time?*



Let *A* represent *Billinsgate stairs*, *D Tulis-stairs*, *A E* the simple motion of the Boat, *E D* the motion of the Current, then is *A* the Angle of Deflection, *E* the Angle of Incidence, *D* the Angle of Reflection 130 *deg.* or 50 *deg.*

As the simple motion of the Boat	*A E* 4 $\frac{1}{2}$ miles	9.34679
Is to the motion of the Tide	*D E* 2 $\frac{1}{2}$ miles	0.39794
So the Sine of Reflection	*D s* 50 *deg*	9.88425
To the Sine of Deflection	*A s* 23 *deg.* 3 *m.*	9.62898

Thus then the Position from *A* to *D*, being South-westerly 40 *deg.*

deg. and the Angle of Deflection *A* 23 *d.* 3 *m.* the position from *A* towards *E*, is South-westerly 63 *d.* 3 *m.* that is, *W S W.* Southerly. And so must those Oars row to go straight over.

Secondly, for the Distance A E.

From the Angle of Reflection	*D*	50 *deg.* 00 *min.*
Substract the Angle of Deflection	*A*	23 *deg.* 03 *min.*
And there rests the Angle of Incidence	*E*	26 *deg.* 57 *min.*

As the Sine of Incidence	*s E* 26 *d.* 57 *m.*	0.34370
To the true Distance	*A D* 80 Poles	1.90309
So the Sine of Reflection	*s D* 50 *deg.* 0 *min.*	9.88425
To the simple motion	*A E* 135 $\frac{3}{10}$ Poles	2.13104

Lastly, *for the time*; seeing 320 Poles make a Mile, and they row 4 $\frac{1}{2}$ Miles an hour, it is 1440 Poles in an hour: so the proportion is,

As the simple hourly motion	1440	6.8416
To the simple motion before found	135 $\frac{3}{10}$	2.1310
So is an hour in Minutes, namely,	60 *min.*	1.7781
To the time required in Minutes	5 $\frac{33}{100}$	0.7507

And so long will they be Rowing over.

9. *But suppose they will row harder, to go a shorter cut; namely, to go Southwest by West: How fast must they go to row straight over, and how far, and in what time?*

Then seeing the Proposition from *A* to *D* is South-westerly 40 *deg.* and Southwest by West is South-westerly 56 *deg.* 15 *m* therefore the Angle of Deflection at *A*, is 16 *deg.* 15 *min.* the Angle of Reflection *D* as before, 50 *deg.* 0 *min.* the Angle of Incidence *E* is 33 *deg.* 45 *min.*

As the Sine of Deflection	*s A* 16 *deg.* 15 *min.*	.55311
To the motion of the Tide	*D E* 2 $\frac{1}{2}$ Miles	0.39794
So the Sine of the Angle of Reflection	*D* 50 *d.* 0 *m.*	9.88425
To the simple hourly motion of the Boat	*A E* 6 $\frac{444}{1000}$	0.83530

And such is the hourly motion of the Boat, namely, 6 $\frac{444}{1000}$ Miles in an hour.

Secondly,

Secondly, for the ſimple motion.

As the Sine of Incidence	*s E* 23 *d.* 45 *m.*	0.25516
It to the true diſtance	*A D* 80 Poles	1.90309
So the Sine of Reflection *D* 50 *deg.* 0 *min.*		9.88425
To the ſimple motion *A E* 110 $\frac{1}{10}$ Poles		2.04260

Thus it appears they muſt Row 110 $\frac{1}{10}$ Poles to get over.

Laſtly, for the time.

The hourly motion before found 6 $\frac{222}{1000}$ reduced into Poles, is		2190 $\frac{1}{10}$
As the ſimple hourly motion	2190	6.65956
Is in proportion to an hour, or	60 *min.*	1.77815
So is the ſimple motion before found	110 $\frac{1}{10}$	2.04260
To the time required	3 $\frac{022}{1000}$ *min.*	0.48031

And ſo long will they be Rowing over.

10. *But admit a Sculler Rowing* 3 *miles an hour, would croſs ſtraight over at the ſame time, upon what Point muſt he row, and how far to get thither, and in what time will he do it?*

First, *For the Angle of Poſition.*

As the hourly motion of the Boat *A E* 3 miles		9.52288
To the ſine of Reflection	*D s* 50 *deg.*	9.88425
So is the hourly motion of the ſtream *D E* 2 $\frac{1}{2}$ *min.*		0.39794
To the Sine of Deflection	*A s* 39 *deg.* 40 *min.*	9.80507

Now ſeeing the poſition for *Billingſgate* to *Tullis-ſtairs*, namely from *A* to *D*, is by ſuppoſition to the Weſtwards of the South 40 *deg.* and the angle of Deflection *A* is here found to be 39 *deg.* 40 *min.* therefore the poſition from *A* to *E* is from the South to the Weſtwards 79 *deg.* 40 *min.* which is *W* and by *S*, and almoſt 1 *deg.* Weſterly, and ſo muſt that *Sculler* row to go ſtraight over. Secondly, *For the diſtance* A E.

From the angle of Reflection	*D*	50 *deg.* 00 *min.*
Subſtracting the angle of Deflection	*A*	39 *deg.* 40 *min.*
There reſts the angle of Incidence	*E*	10 *deg.* 20 *min.*

As the Sine of Incidence	*s E* 10 *deg.* 20 *min.*	.74624
To the true diſtance	*A D* 80 Poles	1.90309
So is the Sine of Reflection	*s D* 50 *deg.* 0 *min.*	9.88425
To the ſimple motion *A E* 341 $\frac{1}{10}$ p.		2.53358

And

And thus it appears, that though the distance of the two places be but 80 Poles, yet if according to the Question, he row but after 3 miles an hour, and the stream set after $2\frac{1}{2}$ miles an hour, then he must row $341\frac{6}{10}$ Poles to go straight over.

Lastly, *For the time.*

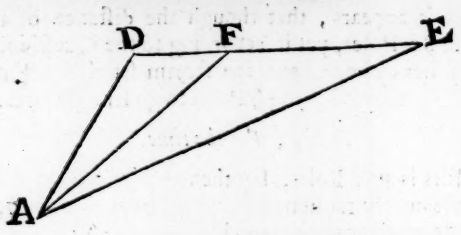
Three Miles is 960 Poles, say then		
As the simple hourly motion	960	7.01773
To the simple motion before found	$341\frac{6}{10}$	2.53358
So is an hour in minutes, namely	60 *min.*	1.77815
To the time required in minutes	$21\frac{11}{100}$	1.32946

And thus it appears, that the time requisite to row over, rowing 3 miles an hour, is $21\frac{11}{100}$ minutes, whereas we found before, that rowing there $4\frac{1}{2}$ miles an hour, they might row over in $5\frac{61}{100}$ minutes, which is little more than a fourth part of the time.

There might be other, and that great variety of Questions of this nature proposed and resolved, many of good use in practice, which the Water-men by daily experience without other Rules, are able to guess at something nearly, sufficing for their occasions: My intent in these is especially to explicate the compound motion of a Ship, or other Vessel, Sailing or Rowing where there is a Current; which by such familiar Examples may seem more evident. I cannot insist upon them by reason of my other occasions, nor spend that time in these here handled, which else I should have done; whence if any defect or mistake should arise, if the Reader be pleased to give me friendly notice of it, I shall as thankfully accept it, and reform it. We purpose next a Question at Sea, which let be this:

11. *There is a Current at Sea setting East 12 miles in 24 hours, a Ship sails in the same from a certain Port West Southwest 6 days, and then returning thence, and sailing N E and by North 3 days, falls with the Port from whence he first departed, I demand what his dead reckoning was outwards, and what back again, and how far these two Ports were asunder, and upon what Point of the Compass?*

As



As let the Current ſet from *E* towards *D*, and let the firſt Port be *A*, the ſecond *F*, and let the Courſe outward bound be repreſented by *A E*, and the Courſe homewards by *D A*, *&c.*

And foraſmuch as *D E* is an Eaſt and Weſt Line, and *A E* Weſt South-weſt, therefore the Angle at *E* is 22 *deg.* 30 *min.* and by the like reaſon, the Angle at *D* is 123 *deg.* 40 *min.* or 56 *deg.* 15 *min.* and the Angle at *A* 33 *deg.* 45 *min.* and *E D* being the ſetting of the Current for 9 days, is 108 Miles.

Firſt then, for the dead Reckoning outwards, namely, A E,

As the Sine of the Angle at *A* s 33 *deg.* 45 *min.*		.25526
To the Line *D E* 108 Miles		2.03342
So is the Sine of the Angle *D* s 56 *deg* 15 *min.*		9.91985
To the Line *A E*	161 $\frac{6}{10}$	2.20853

Thus *A E* his dead Reckoning outwards is 161 $\frac{6}{10}$.

Secondly, for A D.

As the Sine of the Angle *D A E* s 33 *deg.* 45 *min.*		.25526
Is to the Line *D E*	108 Miles	2.03342
So is the Sine of the Angle *D E A* s 22 *deg.* 30 *min.*		9.58284
To the Line *A D*	74 $\frac{4}{10}$ Miles	1.87152

Which 74 $\frac{4}{10}$ Miles is his dead Reckoning homewards.

Thirdly, for the Angle D A F *or* D F A.

The ſide *A D* is found	74 $\frac{4}{10}$ Miles
The ſide *D F* for three dayes, is	36 Miles.
The ſum of both is	110 $\frac{4}{10}$
Their Difference is	38 $\frac{4}{10}$
The ſum of the Angles *D A F* and *D F A*	56 *deg.* 15 *min.*
The half ſum is	28 *deg* 7 $\frac{1}{2}$ *min.*

The

The Proportion.

As the Sum of the ſides	110 $\frac{4}{10}$	7.95703
Is to their difference	38 $\frac{4}{10}$	1.58433
So is the Tangent of	28 *deg.* 07 $\frac{1}{2}$	9.72706
To the Tangent of	10 *deg.* 32 *m.*	9.26932

Which added together, make the Angle *D F A* 38 *deg.* 39 $\frac{1}{2}$.

And ſeeing the Rumb from *F* to *D* is Eaſt, and the Angle *D F A* 38 *d.* 39 *m.* $\frac{1}{2}$, therefore the Rumb from *F* to *A* is to the Northwards of the Eaſt 38 *deg.* 39 *m* $\frac{1}{2}$, that is *N E* by *E* almoſt half a Point Northerly, which is the *Rumb* from the ſecond Port to the firſt. *Laſtly, for* A F *the diſtance of theſe two Ports.*

As the Sine of the Angle	*D F A*, ſ 38 *deg.* 39 $\frac{1}{2}$	.20434
To the dead Reckoning Homewards	*A D* 74 $\frac{4}{10}$ Miles	1.87152
So is the Sine of the Angle	*D* ſ 56 *deg.* 15 *min.*	9.91985
To the Diſtance	*A F* 99 $\frac{003}{100}$ Miles	1.99571

Thus the true diſtance of thoſe two Ports is 99 Miles, and ſomewhat more.

Sundry other Queſtions of like nature might be propoſed, which to him that well underſtandeth, theſe will not be difficult.

Theſe Principles a little inlarged, may further with a few Experiments be applyed in the diſcovery of ſome Myſteries in compound motions not yet divulged; though much endeavoured by ſundry Famous Men in ſeveral parts of *Europe*; but theſe we ſhall not touch at preſent.

12. *To find where there is a Current at Sea, alſo which way it ſets, and how faſt.*

THis may be done by comparing the Reckoning outwards with the Reckoning homewards, whereof we will give an Example or two.

Firſt, admit a Ship Sail from a certain Port, by one or ſeveral (Rumbs or Diſtances,) till ſhe arrive at the ſecond, and there find Reckoning by Courſe and diſtance, that ſhe is more Southerly than the Port from which ſhe departed by 541 Miles, and more Weſterly by 145 Miles: But by his Reckoning homewards,

wards, when he arrives again at the firſt place, he finds himſelf to the Northwards of the ſecond 541 Miles, as before, and to the Eaſtwards 305 Miles. Now ſuppoſing he were 3 days outwards bound, and 5 days homewards bound, I would know which way the Current ſets, and how faſt? Here, becauſe the Eaſterly diſtance homewards is greater than the Weſterly diſtance outwards, therefore from the Eaſterly diſtance 305 Miles, ſubſtract the Weſterly diſtance 145 Miles, the remainder being 160 Miles, is the motion of the Current to the Weſtwards.

And thus it appears, that the Current ſets to the Weſtwards, 160 Miles in eight days, that is, 20 Miles a day, or $\frac{1}{6}$ of a Mile every hour.

2. *Example.* Admit a Ship Sail from the *Summers-Iſland*, by ſeveral Rumbs and diſtances, till ſhe arrive at Cape *Codd* in *New-England*, namely, from the Eaſt part of *Summer-Iſlands* (the Variation being allowed) firſt, North 20 Miles, and then *NNW* 150 Miles, the ſecond day *N* by *W* 180 Miles: The

	North.	*South.*	*Eaſt.*	*Weſt.*
North 20 Miles	20 0			
North North Weſt 150 Miles	138 6			57. 4
North by Weſt 180 Miles	176 5			35. 1
North 90 Miles	90 0			
North Eaſt 88 Miles	62 2		62 2	
528 Miles	487 3		62 2	92. 5
				62. 2
				30. 3

third day North 90 Miles, the fourth day North Eaſt 88 Miles, and ſo arrive at Cape *Codd*: Then by theſe Courſes and diſtances we may gather by the foregoing Table, that Cape *Codd* ſhould by this Reckoning be to the Northwards 487 Miles: And to the Weſtwards 30 Miles, as here appears.

Now ſuppoſe ſhe Sail back again from Cape *Cod* towards the *Summer-Iſlands*, the firſt day *SSW* 150 Miles, the 2 day *SSW* 160 Miles, the third day *S* by *W* 130 Miles, the fourth day South 140 Miles, the fifth day Eaſt 110 Miles, and ſo be come again to the Eaſt part of the *Summers-Iſlands*.

South

	North	*South.*	*East.*	*West.*
South S W 150 Miles	———	138. 6	———	57. 4
South S W 160 Miles	———	147. 8	———	61. 3
South by W 130 Miles	———	127. 5	———	25. 3
South 140 Miles	———	140. 0	———	———
East 110 Miles	———	———	110. 0	———
690 Miles		554. 0	110. 0	144. 0
				110. 0
				34. 0

These Courses and Distances make, as here appeareth, the *Summer-Islands* to be to the Southwards of Cape *Coda* 554 miles, and to the Westwards 30 miles.

Therefore by this last Reckoning back again, Cape *Codd* should be to the Northwards of the *Summer-Islands* 554 Miles, and to the Eastwards 34 miles, whereas by the former Reckoning outwards, it was to the Northwards only 487 miles, and to the Westwards 30 miles; so that the difference of these two Reckonings outwards and back again, is 67 miles Northerly, and 64 miles Easterly, which sheweth that the Current in that time, namely in Nine days, hath set to the Northwards 67 miles, and to the Eastwards 64 miles; that is, North East a little Northerly, 93 miles, as by the fore-going Table doth appear, which is $10\frac{1}{3}$ miles every day.

And what we have here done by the Tables might have been done (as the fore-going Problems) by the *Doctrin of Plain Trianglee.*

FINIS.

Mathematical and Sea-Books Printed for and sold by William Fisher, *Bookseller, at the ancient Shop by the Postern on* Tower-Hill; *and* Eliz. Hurlock, *at the* Rose, *at the West-end of St. Paul's Church*, viz.

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